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SURFACE GROWTH OF NEW ZEALAND TOWNS*

L. L. POWNALL

OVER the past fifty years a proportionately greater number of New Zealanders have resided in towns. Today urban settlements are the living quarters and work places in which nearly two-thirds of the people spend their lives. To accommodate the steadily increasing number of urban dwellers the towns themselves have of necessity expanded in physical extent, replacing with orderly blocks of suburban housing the farmlands which once surrounded them. All of this is well appreciated by most New Zealanders. But the way in which New Zealand towns appear to increase their superficial extent is less well understood. This paper sets out the results of an investigation into the manner in which some New Zealand towns appear to grow.

DATA EMPLOYED

The analysis of superficial growth is based on detailed reconstructions of the physical extent of various New Zealand towns at different stages in their evolution. The choice of towns for examination was decided almost completely by the availability of source material.

Unlike older countries, where topographic mapping has been carried out for a considerable period of time, the publication of topographic maps in New Zealand dates only from the early years of this century when maps of the four metropolitan centres were made in the field. These maps were published either immediately preceding, or immediately following, World War I, with or without revision. Because of the paucity of topographic survey data, and the absence of a national archive or map bibliography in New Zealand, the geographer is virtually dependent for his reconstruction of urban areas on materials other than topographic sheets, notably plans of standard surveys, maps prepared by business firms and local authorities for their own purposes, photographs, and sketches. While standard survey records of a town are lodged in the local district office of the Lands and Survey Department, not all standard surveys show buildings in existence at the time of the survey.

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*The field work and archival research on which this paper is based was made possible by the Research Grants Committee of the University of New Zealand to whom acknowledgement is made.

In general it may be said of New Zealand that the specialised historical data of the type necessary for urban reconstructions are to be found in a variety of places: in government departments, museums, local authority offices, art galleries, universities, libraries, commercial and professional offices, shops, and private homes. From these sources they can sometimes be unearthed by a combination of a little patience, moderate perseverance, and a large measure of luck.

This data, together with a map of the contemporary form of a town, when draughted at a common scale, provide visual evidence of the process followed by a town in its surface growth. (See accompanying maps).

SURFACE GROWTH

Analysis of the superficial growth of some twenty-three samples suggests that New Zealand towns do not increase their area by the addition of concentric layers, nor by development around a number of dispersed nuclei (Balclutha, Blenheim, Dargaville, Dunedin, Fielding, Gisborne, Invercargill, Masterton, Morrinsville, New Plymouth, Oamaru, Palmerston North, Picton, Putaruru, Rangiora, Russell, Timaru, Waipukurau, Wairoa, Waitara, Wanganui, Wellington and Whakatane.) Rather it would seem to follow a process of sector expansion somewhat akin to the wedge theory advanced by Hoyt.[1]

The wedge hypothesis has been succinctly described as follows:

> According to the theory, growth tends to proceed from any point of origin along transportation routes towards high ground which is free from floods or atmospheric pollution and has scenic interest, and along waterfronts not used for commerce or industry, and tends to avoid 'dead-end' directions in which growth is limited by natural or artificial barriers. The highest density of development is along the wedges that are served by the best transportation routes . . . . Once started in a particular direction, urban growth tends to retain similar characteristics as it proceeds outward along the wedge. The resultant urban form is often that of a star or diamond, depending upon the number

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[1] Homer Hoyt: *The Structure and Growth of Residential Neighbourhoods in American Cities*, Washington, 1939.

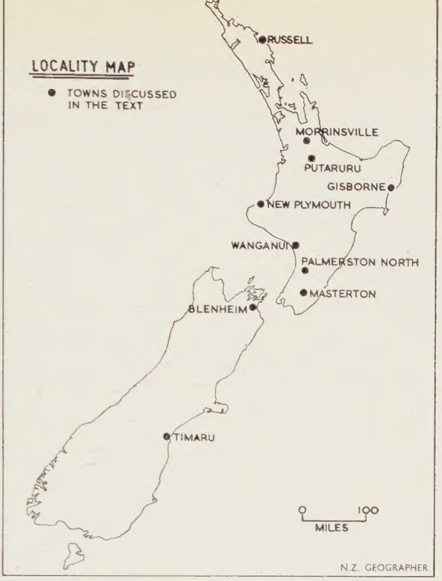

Fig. 1. The location of towns discussed in the text

> of major radiating routes. Protuberances and higher density development take place along the main transportation lines.[2]

Two parts of this hypothesis would seem to apply to New Zealand conditions. Surface growth has undoubtedly been affected by drainage, slope, and scenic interest; and the highest density of development (in a dynamic sense) has occurred along wedges best served by transport. But the concept cannot be accepted as applying to New Zealand towns that 'once started in a particular direction, urban growth tends to retain similar characteristics as it proceeds outward along the wedge.' This is not the case in New Zealand towns; nor are the resultant urban forms often those of a star or a diamond. In fact, out of a total of forty-eight nucleated settlements examined in New Zealand, only Christchurch and Hamilton have developed outlines nearly approximating these forms. Most towns are amorphous, rectangular, or elongated. Considerable modification of this wedge hypothesis therefore seems necessary if the growth pattern of New Zealand towns is to be explained satisfactorily.

One proposal which would seem more satisfactory for New Zealand towns has three significant variants from the wedge hypothesis. First, while accepting the opinion that urban development tends to proceed in the form of wedges, it describes sector expansion as a process of scattering buildings lightly over one or two sectors of the site; subsequently there is consolidation among the scattered buildings, and at the same time first stage development proceeds in another sector. Second, it suggests that new sectors, when developed beyond the established perimeter, are of an essentially different character from the older sectors they adjoin. And third, it suggests that modifications to the internal characters of older sectors are proceeding simultaneously with new growth. This theory may be shown schematically (*Fig.* 2), and its several stages may be described in sequence.

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[2] Harold M. Mayer (*et al.*): 'Urban Geography', in Preston E. James and Clarence F. Jones (Eds.): *American Geography: Inventory and Prospect*, Syracuse, 1954, p. 153. For other discussions of urban growth see also: P. Geddes: *Cities in Evolution*, London, 1915; Sten de Geer: 'Greater Stockholm, a Geographical Interpretation', *Geogr. Rev.*, Vol. 13, 1923, pp. 487-500; A. Demangeon: *Paris, La Ville et sa Banlieue*, Paris, 1933; J. H. von Thünen: *Der Isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie*, Jena, 1910, described in R. E. Dickinson: *City, Region, and Regionalism*, London, 1947, p. 192; E. W. Burgess: 'The Growth of the City', in R. E. Park, E. W. Burgess, and R. D. McKenzie (Eds.): *The City*, Chicago, 1925.; M. R. Davie: 'The Pattern of Urban Growth', in G. P. Murdock (Ed.): *Studies in the Science of Society*, New Haven, 1937; and C. D. Harris and E. L. Ullman: 'The Nature of Cities', *Annals of the American Academy of Political and Social Science*, Bulletin 242, 1945, pp. 7-17.

The nucleus of almost every urban centre in New Zealand, other than gold-mining settlements, comprised a loose grouping of stores, accommodation houses, private residences, and an occasional industrial building, such as a smithy. Outside of this core, residential areas grew up in the vicinity of the main outlets from the settlement (*Fig.* 2, Stage 1).

With the growth of population, additional sectors were subdivided for housing and in them new residences were lightly scattered; settlement in the older residential sectors was consolidated; and the business area expanded slightly (Stage 2). At the same time a few retail shops were erected on the main roads beyond the limits of the business district, while an isolated industry or two had started in the older residential areas. With the arrival of the railway, new factories were put up in its vicinity, such as flour mills, and timber yards. Here also were erected the gasworks and the produce stores. As a result the railway became the focus of the main industrial and storage area of the township, exclusive of the central business district.

This overall design changed as further housing sectors of different quality developed and as consolidation continued in the older quarters (Stage 3). Once again the business area expanded, this time along the main highway as well as towards the areas of earliest residential construction. Further retail shops were erected at approximately the same time among the stores dispersed outside the central business district, and these changes initiated a new cycle.

More residential areas were opened and a few noxious industries formed the embryo of a factory area near the railway, outside the built-up limits of the town. Most strikingly of all, factories appeared among the dispersed lines of retail shops, and 'backyard' factories and a small number of suburban shops were built indiscriminately in the older

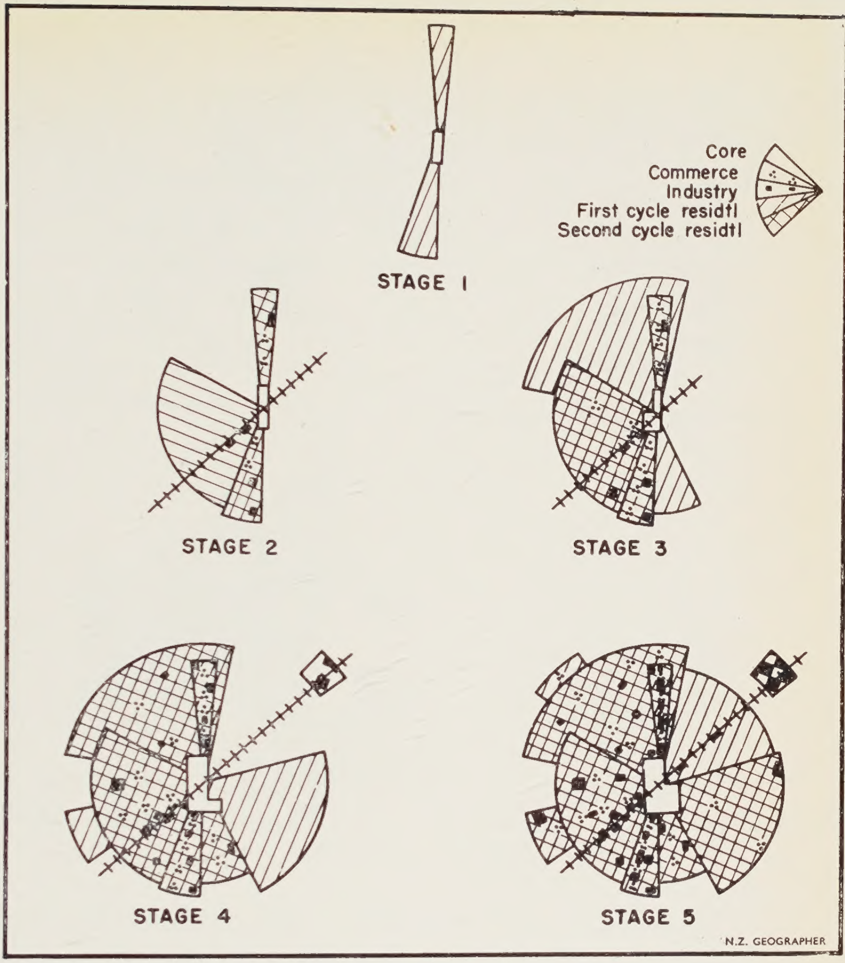

Fig. 2. Urban growth by sectors

housing sectors (Stage 4). However, the main industrial area (as such) remained in the neighbourhood of the railway where other factories had been built. Again each of these areas underwent modification.

The same sequence of residential expansion and consolidation was followed. The noxious factory area attracted further factory units, and the central business district expanded slightly. Shops and factories at this stage formed continuous strips along the line of the two major outlets from the town, while a string of dispersed retail shops had formed along a third highway (Stage 5).

Within most residential sectors the number of small factories and suburban stores had also increased, even the sectors of most recent development being pock-marked by factories, and dotted with retail shops. The only areas to escape invasion were those in which residential values were highest. Even in those areas the passage of time and natural decay would seem almost inevitably to expose their purely

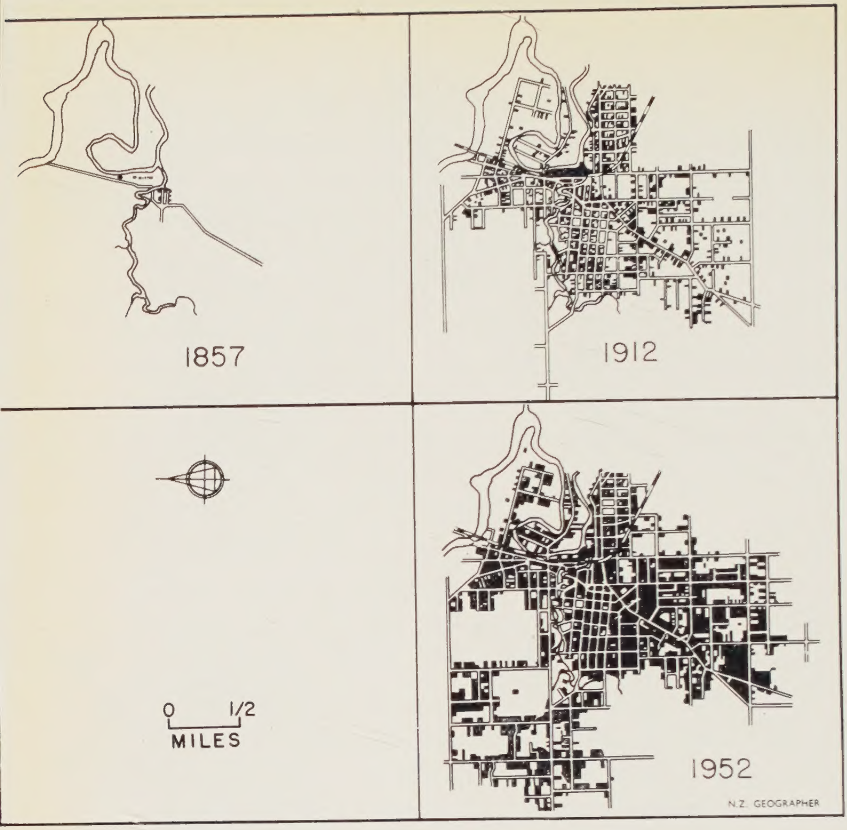

Fig. 3. Surface growth of Blenheim

residential character to invasion by shop and factory, pushing out along the main streets, or expanding around the core of a backyard factory, such as had already occurred in the oldest residential districts—now the areas of lowest residential quality.

Although this evolutionary sequence is in a sense hypothetical and idealised—since it does not draw on the history of any specific urban centre but on the story of many New Zealand towns—nevertheless, every urban centre provides examples of most, if not all, of the stages outlined. Some examples will suffice to illustrate this. First, the development of Blenheim and Palmerston North is used for this purpose. Today Palmerston North is the seventh largest urban area in New Zealand with 37,751 people in the urban area at the 1956 census, and Blenheim has a population of some 9227.

BLENHEIM

The deltaic plain of the Wairau is crossed by the Wairau River and its major distributaries, the Opawa and the Omaka, which wander across the relatively flat surface with many loops and meanders. It was near the junction of the Opawa and the small Omaka that Blenheim was

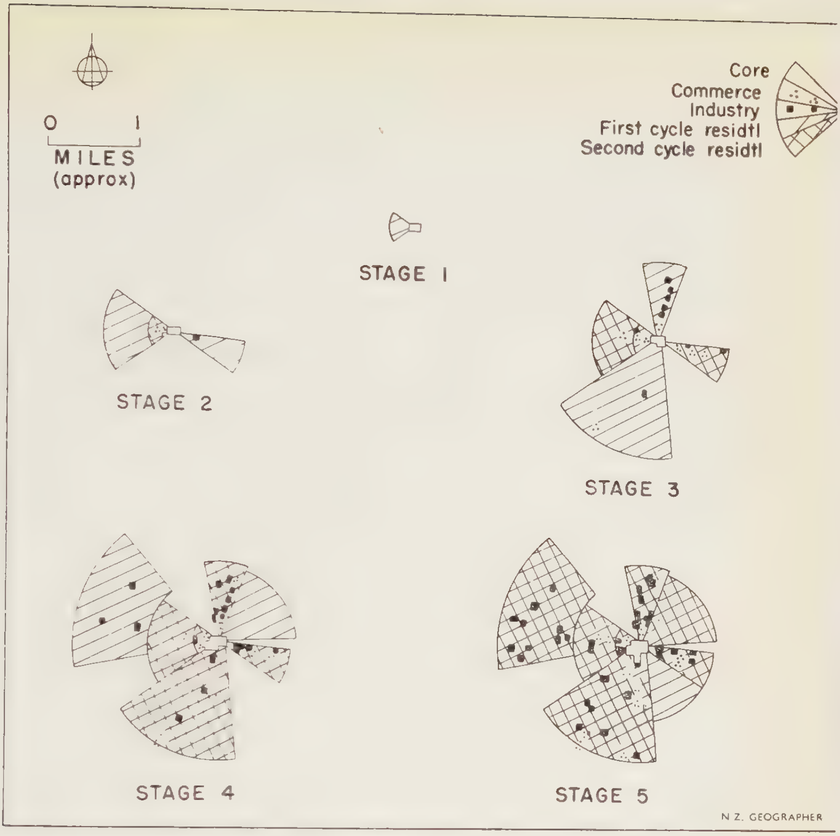

Fig. 4. Schematic growth of Blenheim

first laid out. The site—like most of the delta—was low-lying and swampy, but chosen because the Omaka was navigable by ships' boats up to this point.

In its evolution Blenheim grew up around the core of streets first surveyed for the town. In so doing it neglected at first the slightly higher ground on the southern edge of the borough, preferring instead the swamp beds and shallow stream courses adjacent to the rivers which comprised much of the area subdivided for initial settlement (*Fig.* 3, 1857). On the north the growing township was bounded by rivers, and, because of the lack of bridges, settlement on that side of the town was severely restricted for some time. Instead, houses were scattered in the area of the original survey to the west of the business area along the main road leading to the parent settlement at Nelson (*Fig.* 4, Stage 1). A further subdivision soon followed on the eastern side, in the vicinity of the main south highway. Houses, shops, and factories began to be erected here later, as well as on the outer fringes of the western side (*Fig.* 4, Stage 2). In the older part of the latter area residential buildings had consolidated, while one or two shops—and an occasional hall—had also opened.

With the bridging of the steep-sided river and the opening of the railway to the port of Picton, bulk stores, industrial premises, and houses were put up in the vicinity of the railway yards and along the Blenheim-Picton highway, which led north from the town (*Fig.* 3, 1912). A similar scattered development also took place in the neighbourhood of the southern outlet from the old core (*Fig.* 4, Stage 3).

In succession further buildings were scattered on county land to the west of the town and into the area most prone to flooding in the north-eastern quadrant, as consolidation proceeded in the older quarters (*Fig.* 4, Stage 4). As more buildings were added in these youthful areas, the number of factories also increased in every sector of Blenheim, while further stores appeared haphazardly on the main outlets and in the surburban areas away from the main roads (*Fig.* 4, Stage 5). In this manner Blenheim achieved its present form (*Fig.* 3, 1952).

Successively Blenheim developed over the first fifty years, first, around the earliest buildings, then to west and east of this grouping, and finally on the northern and southern sides. The various sections of the town which were partially occupied by buildings at each of these stages differed considerably in the area they occupied, but all followed the same sequence of a scattering of buildings over an appreciable sector and later consolidation within these limits. Most sections also underwent changes in function and morphology.

Palmerston North

A broadly similar mode of growth to that of Blenheim is shown in the evolution of Palmerston North. The site of Palmerston North comprises four broad river terraces of varying size but of uniformly slight elevation on the western bank of the Manawatu River. In its primitive state the delta plain of the Manawatu was thickly forested. The existence of a large clearing in the heart of this forest was therefore considered by government surveyors a fortunate site on which they might lay out a town. Under their direction a grid pattern of streets was planned around a large central square.

The initial pattern of commercial development was around the northern edge of the Square and along the tramway line which led into the forest at the eastern end of the clearing (*Fig.* 5, 1872). The residential area on both sides of this railway maintained its importance during the first decade. The main roads to the northwest and southeast, leading

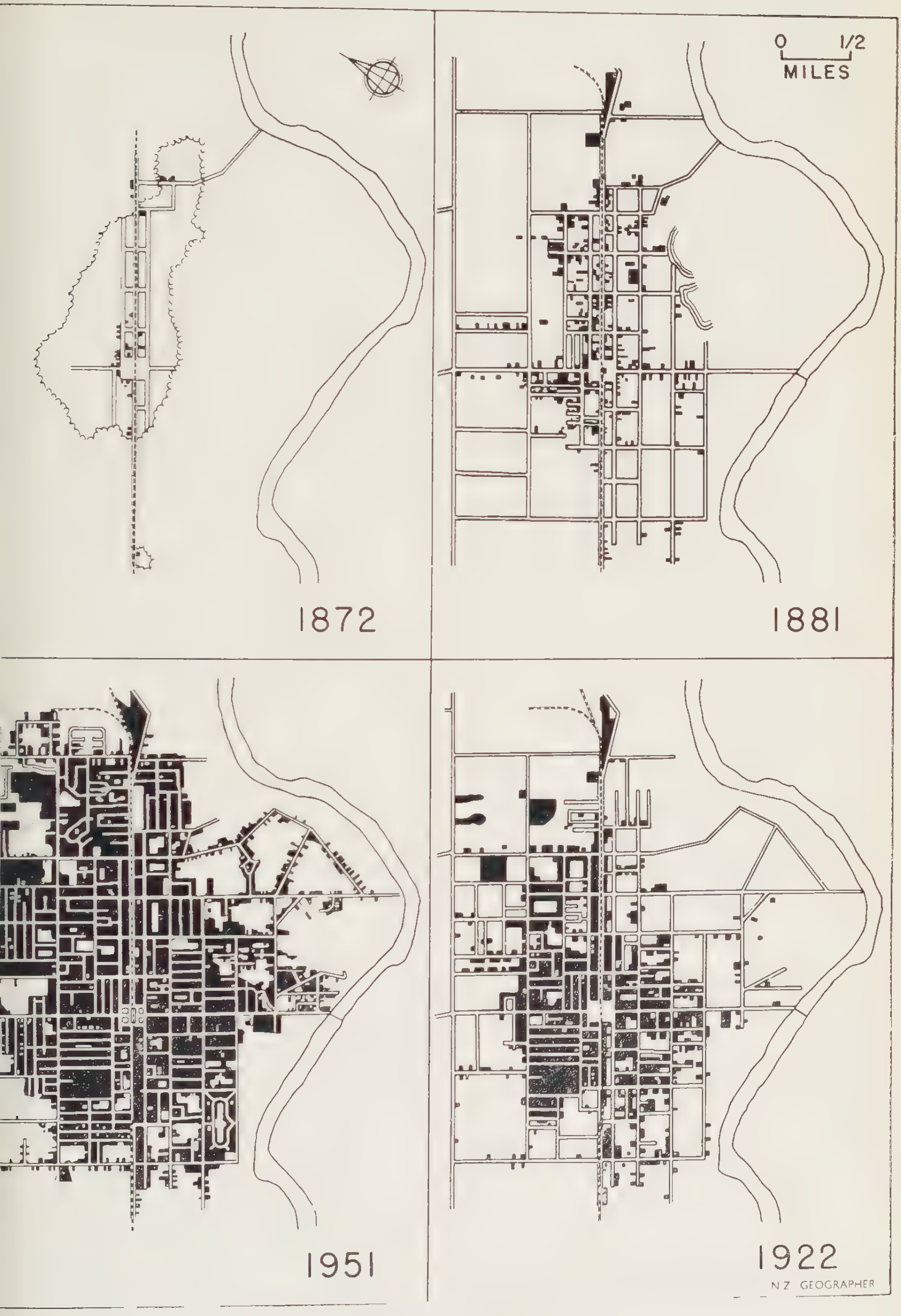

Fig. 5. Surface growth of Palmerston North to Wanganui and Wellington respectively, had also attracted buildings, while the major housing development had taken place in a compact area of closely subdivided land to the west of the Square (*Fig.* 6, Stage 1). In two other sections, small but compact residential development had also occurred after a few years, although for the most part the town appeared to be growing as a result of the subdivision of a few individual blocks or street frontages and the sprinkling of houses within these areas. Thus, by 1881 extensive areas still remained without urban buildings (*Fig.* 5, 1881). An embryonic industrial area had also formed along the railway (*Fig.* 6, Stage 2).

Consolidation and Expansion

After another forty years the process could be seen even more clearly (*Fig.* 5, 1922). The construction of additional streets in those parts of the town in which subdivision had been carried out at an early date, had resulted in the closer settlement of these areas, and factories were appearing in some blocks. By this process the town had developed a reasonably compact shape (*Fig.* 6, Stage 3), except that a second scattering of houses had appeared along road frontages just outside the limits of the built-up section. The core had also enlarged; factories and shops were consolidated along the eastern outlet; and suburban shops were appearing indiscriminately on the main thoroughfares which joined the suburbs to the core.

Between 1922 and 1951 a narrow band of new residential development had been added on the western side of the town, a new sector had opened on the east, and factories had multiplied in the older sectors of the town (*Fig.* 6, Stage 4). By 1951 these fringe areas had been consolidated, additional factories erected, and the land in the eastern and western parts had in turn developed an outer fringe of scattered buildings.

The present form of Palmerston North may thus be accounted for by this process of subdivision of individual street blocks adjacent to the core of settlement, the scattering of buildings, and consolidation accompanied by successive changes in composition. While one part was being consolidated, another was being subdivided and lightly settled, and the composition of a third—or fourth—was undergoing modification.

Blenheim and Palmerston North are not isolated examples of this mode of development. Two other examples may be cited briefly of smaller agglomerated settlements: the oldest European settlement in New Zealand, infamous Kororareka; and one of the youngest towns in the Dominion, Putaruru, market centre of the northwestern fringe of the North Island's Volcanic Plateau (*Fig.* 1).

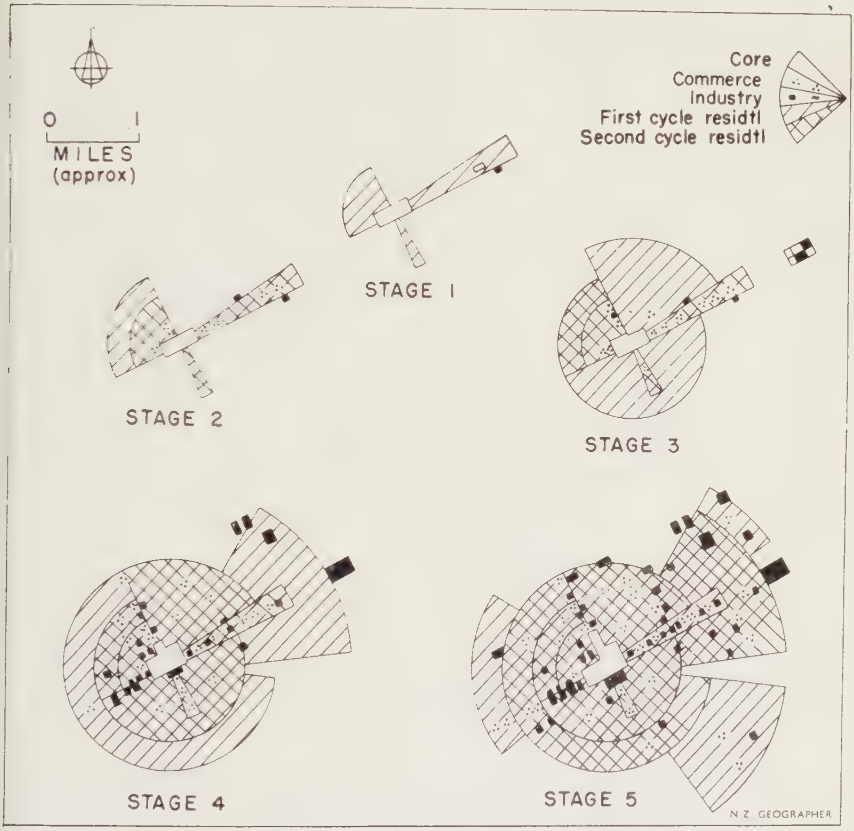

Fig. 6. Schematic growth of Palmerston North

Russell and Putaruru

The tourist and deep-sea fishing centre of Russell— once Kororareka —occupies a small pocket of land in Kororareka Bay and its adjoining cove, on the western side of a narrow peninsula in the Bay of Islands. The small bayheads are joined by a narrow valley which isolates a small headland from the other steep slopes of the fringing hills. The floors of both bayheads are crossed by small creeks, the largest of these pro-

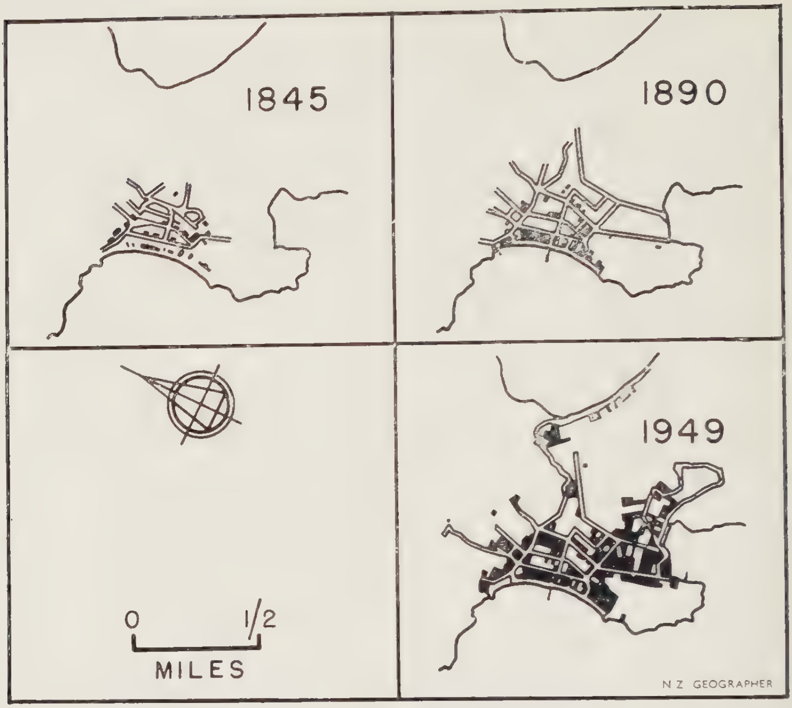

Fig. 7. The growth of Russell

ducing swampy conditions on the flat behind Kororareka Bay. Early in the nineteenth century two small Maori villages were situated on this beach just above high water mark. Here European and American whalers, sealers, and traders found safe anchorage, fresh water, and trade goods, and Maori chieftains acted as pimps.

Early Europeans who settled here scattered their churches, houses, stockades, and government offices on some of the flat land and on the lower slopes of the surrounding hills, although they avoided the swampy patches (*Fig.* 7, 1845). The two or three business premises and administrative offices were all erected along the waterfront. For the first fifty years or more the whole village was contained within the bayhead (*Fig.* 7, 1890) until the shortage of suitable building sections produced a scattering of houses in appreciable numbers across the lower portions of the adjoining cove. This was followed, under pressure, by consolidation and the spread of the township higher up the hillsides and beyond the ridge onto the northern beach (*Fig.* 7, 1949). At the same time new business premises were erected on the main trafficway into the town, one block back from the beach, and a fish-processing

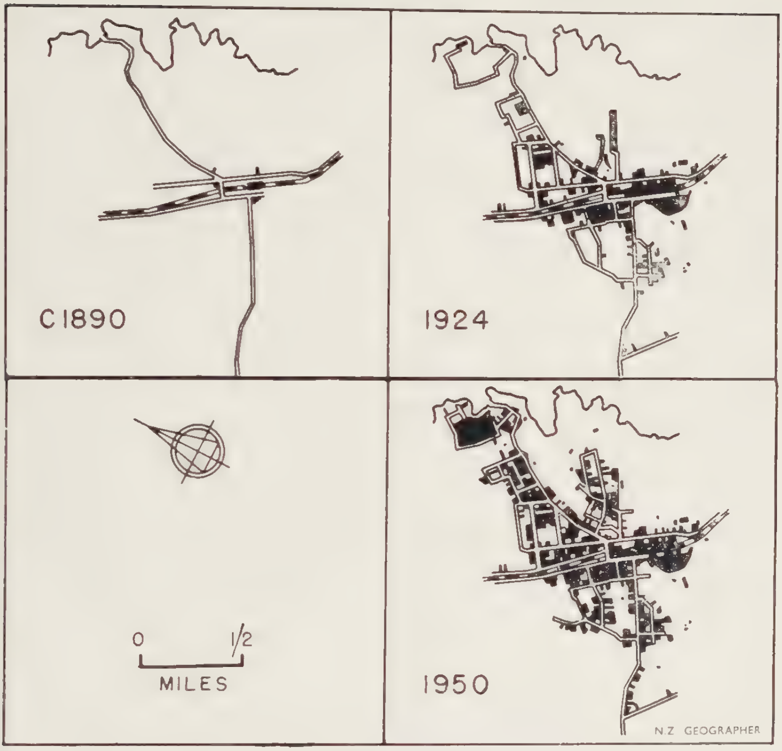

Fig. 8. The growth of Putaruru

factory was opened on the southwestern edge of the smaller cove. However, even today, consolidation is by no means complete.

Putaruru is much more prosaic in its origin although it has apparently followed the same mode of surface growth. The site of Putaruru is exclusively one of low to undulating surface. It is part of an old alluvial valley and its surface is scarred by several shallow gullies.

The settlement of Putaruru in 1886 consisted of 'little more than a blacksmith's shop and hotel'. Even four years later only a general store and a railway station had been added (*Fig.* 8, c. 1890). As the town increased in population it expanded along the general axes of the railway line and the main road through the settlement while avoiding the land of steeper slope. In so doing it scattered houses lightly into two main sectors to the northeast and southwest of the initial core (*Fig.* 8, 1924). Coincident with these developments, business premises had spread in opposite directions along both sides of the main highway from the point where it crossed the railway line. A large timber mill had also opened at the southern end of the town (*Fig.* 8, 1924). Finally, it may be noted once again that most residential development in Putaruru over the past thirty years has been in those areas in which some buildings had already been erected by the mid-1920's.

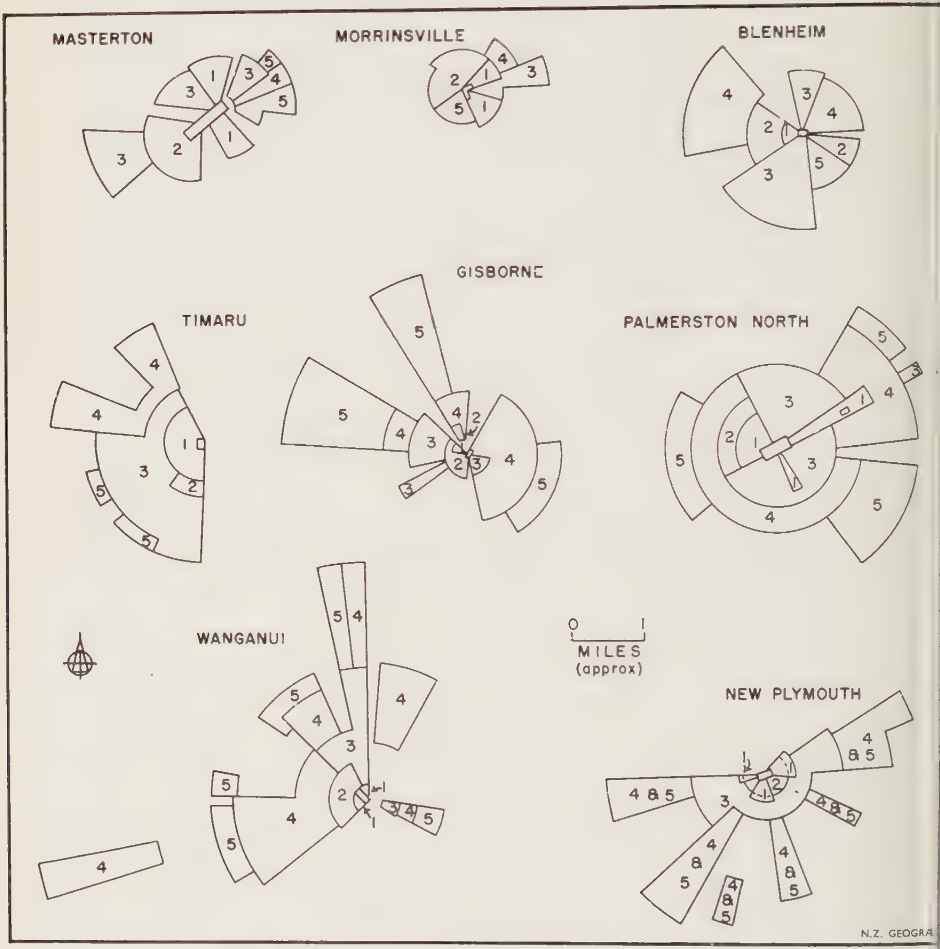

Fig. 9. Schematic representation of urban growth by sectors

A number of other examples might equally well have been cited; however, instead of doing so, the schematic representation of their surface growth may merely be shown (*Fig.* 9).

What explanation can be offered for this apparent mode of surface growth on the part of several New Zealand towns of widely different size, site condition, age, and historical circumstance? Quite evidently no single factor is invariably responsible for this complex evolutionary process although transport and surface configuration come closest to having a predominant role.

Apparent conformality between surface conditions and superficial growth is most strikingly exemplified in New Zealand by the town of New Plymouth, when maps of surface slope and historical evolution are compared (*Figs.* 10 and 11). However, slope is rarely an absolute deterrent to urban growth; even the precipitous cliff face that bounds the original core of Whakatane has not prevented the development of a residential district on the headland above the rest of the town.

TRANSPORT AND TOWN GROWTH

The existence of transport arteries has undoubtedly affected the order in which urban sectors have developed, although the locality, or 'prestige' value of a certain area, particularly in the larger New Zealand towns, sometimes appears to be of considerable—if not equivalent—importance in explaining a particular pattern of growth. At the same time, one of the most significant forces making for internal modification to the character of some areas is a change in volume of traffic; for example, the displacement of the railway from its position as primary passenger carrier, linking tributary region and local centre, had a profound effect on parts of the central business districts of many New Zealand towns, since the volume of pedestrian traffic between railway station and retail district declined sharply. Conversely, an increase in the volume of vehicular or pedestrian traffic has tended to stimulate the erection of commercial and industrial units along a thoroughfare, thereby affecting not only the character of the development along the highway itself, but also the structure of land use in the adjacent street blocks.

Variations in building codes and taxes among local authorities in the same urban area have also influenced the direction of growth of some New Zealand urban areas, and have produced changes within their built-up quarters. Differences in retail shopping hours from one part of a town to another, land speculation, and the alienation of large tracts of land by institutions are influences which are all represented in some New Zealand town. Age also brings change to everything. This is everywhere obvious to the eye in the New Zealand town, where the bulk of the houses are built of wood.

In explanation of the apparent mode of surface growth followed by a specific urban area in New Zealand, a special combination of these

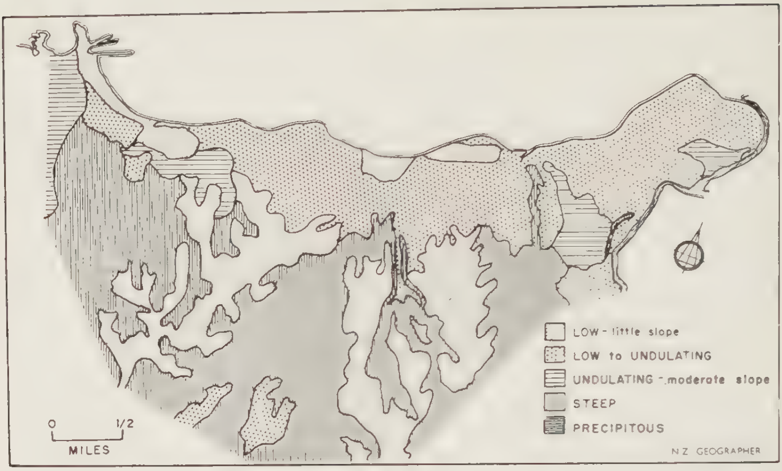

Fig. 10. Surface slope of New Plymouth

factors applies, although almost always bulking large are the effects of surface configuration and transport. It would seem, therefore, that while a general hypothesis may be postulated which would seem to describe generally *how* some New Zealand towns have grown superficially, no universally satisfactory explanation has yet been advanced to explain *why* this apparently common mode of growth has occurred under geographic conditions which are so often markedly dissimilar.

NOTES ON MAP SOURCES:

Fig. 3. The growth of Blenheim. Based on the following sources: 1857 – Alfred Dobson, *Plan of the Town of Beaver, Wairau Plain, Province of Nelson* Scale 1 inch to 3 chains, 1857, showing distribution of buildings, edge of swamp and watercourses, and proposed street pattern, in Lands and Survey Department, Blenheim; 1912 – John Sturrock, *Blenheim Waterworks Plan*, Scale 1 inch to 10 chains, 1912, showing roads and buildings, to accompany *Report on A Sewerage and Water Supply Scheme For The Borough of Blenheim*, November 1912, in Blenheim Borough Council; 1952 – Blenheim Borough Council, *Urban Land Use Map of Blenheim*, Scale 1 inch to 8 chains, 1952, in Blenheim Borough Council.

Fig. 5. The growth of Palmerston North. Based on the following sources: 1872 – Henry Jackson, *Plan of Town and Suburban Sections, Palmerston North, Manawatu*, Scale 1 inch to 10 chains, 1872, showing bush line, roads, and buildings, in Palmerston North City Council; 1881 – Palmerston and Scott, *Plan of The Borough of Palmerston North in The County of Manawatu, Provincial District of Wellington, N. Z.*, Scale 1 inch to 8 chains, 1881, showing buildings, roads, and bush line, in Palmerston North City Council; 1922 – oblique aerial photographs of Palmerston North, 1922, in Palmerston North City Council; 1951 – Palmerston North City Council, *Urban Land Use Map of Palmerston North*, Scale 1 inch to 5 chains, 1951, in Palmerston North City Council.

Fig. 7. The growth of Russell. Based on the following sources: 1845 – Sketch of Kororareka in 1845 in Arthur S. Thomson, *The Story of New Zealand, Past and Present – Savage and*

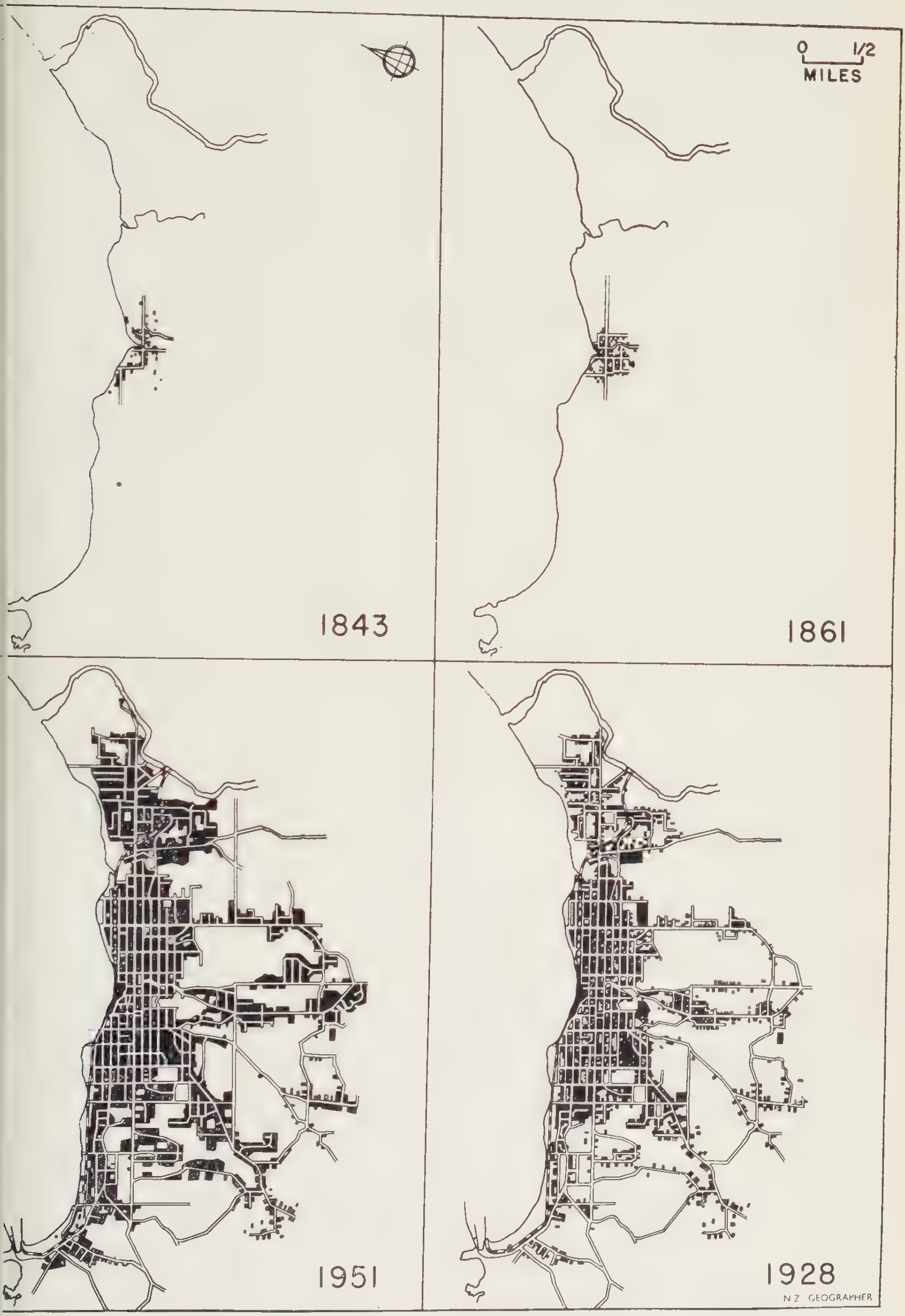

Fig. 11. The growth of New Plymouth

Civilised, London, 1859, Vol II. p. 105; 1890 – W. J. Wheeler, *Russell Township*, Scale 1 inch to 2 chains, 1890, showing streets and buildings, in Lands and Survey Department, Head Office, Wellington; 1951 – field survey by the author.

Fig. 8. The growth of Putaruru. Based on the following sources: c. 1890 – photo of Putaruru, circa 1890, in the possession of J. R. O. Lochhead, Putaruru, who helped in the identification of the buildings in the field and to whom grateful acknowledgement is made; 1924 – G. G. Griffiths (*et al.*), *Land Use Map of Putaruru*, Scale 1 inch to 4 chains, showing buildings, and existing and proposed streets, in the possession of J. R. O. Lochhead, Putaruru; 1950 – field survey by the author.

Fig. 9. The schematic growth of some New Zealand Towns by sectors. Based on the following sources: *Masterton* 1880 – L. Smith, *Standard Survey of Masterton*, Scale 1 inch to 1 chain, 1880, showing name of occupiers and positition of buildings, in Masterton Borough Council; 1905 – C. A. Mountfort, *Borough of Masterton, Standard Survey*, Scale 1 inch to 1 chain, 1905, showing location of all buildings within the borough excluding central commercial area, in Lands and Survey Department, District Office, Wellington; 1931 – Masterton Borough Council, *Borough of Masterton*, Scale 1 inch to 5 chains, 1931, showing urban land use, in Masterton Borough Council; 1951 – Town and Country Planning Branch of the Ministry of Works, *Urban Land Use Maps of Masterton*, Scale 1 inch to 10 chains, 1951, in Ministry of Works, Wellington. *Morrinsville* 1906 – J. A. Pickett, *Assets Realization Map*, Scale 1 inch to 5 chains, 1906, showing buildings and streets, in Morrinsville Borough Council; 1929 – Morrinsville Borough Council, *Civic Survey of Morrinsville*, Scale 1 inch to 5 chains, 1929, showing urban land use, in Morrinsville Borough Council; 1949 – Town and Country Planning Branch of the Ministry of Works, *Civic Survey of Morrinsville*, Scale 1 inch to 5 chains, 1949, showing urban land use, in Ministry of Works, Wellington. *Timaru* 1853 – Pencil sketch of 'Messrs. Rhodes' home station on the beach at Timaru with a view of Arowhenua Bush on the Plains and Talbot Forest', by W. D., checked against B. Woolcombe, *Timaru Roadstead Surveyed*, Scale 1 inch to 800 feet, 1858, showing coastline, store, woolshed, and landing places, in Timaru Harbour Board; 1875 – Lyttleton Times Co., *Plan of Timaru Township, Canterbury*, Scale 1 inch to 3 chains, 1875, showing streets, sections, buildings, parks, in Lands and Survey Department, Head Office, Wellington; 1939 – Timaru Borough Council, *Civic Survey of Timaru*, Scale 1 inch to 8 chains, 1938, showing urban land use, in Timaru City Council; 1952 – field survey by the author. *Gisborne* 1871, 1876, 1887 and 1908 – photos of Gisborne at these dates from the same spot on Kaiti Hill, in possession of Gisborne Old Folks Incorporated, and James Crisp, Jun.; 1950 – Town and Country Planning Branch of the Ministry of Works, *Urban Land Use Map of Gisborne*, Scale 1 inch to 5 chains, 1949, in Ministry of Works, Wellington. *Wanganui* 1844 – F. A. Sheppard, *Plan of the Town of Petre in the District of Wanganui*, Scale 1 inch to 10 chains, 1844, showing streets, occupied sections and proposed reserves and public buildings, in Lands and Survey Department, Head Office, Wellington; c. 1860, c. 1880, and c. 1900 – photos of Wanganui at these dates from the same spot on Durie Hill, in possession of S. R. McCallum, Wanganui; 1950 – field survey by the author.

Fig. 11. The growth of New Plymouth. Based on the following sources: 1843 – (Sketch of) 'The Town of New Plymouth in the year 1843', by Mrs Wickstead, checked against (Sketch of) 'New Plymouth in 1844', by Edwin Harris, both of which are in the Taranaki Museum, New Plymouth; 1861 – N. Z. Survey, *New Plymouth*, Scale 1 inch to 5 chains (approx.), 1860-61, showing buildings and lines of trenches completely encircling the town, in Lands and Survey Department, Head Office, Wellington; 1928 – New Plymouth Borough Coucil, *Sewerage Plans of New Plymouth*, Scale 1 inch to 2½ chains, 1928, showing buildings, streets, and sewers, in New Plymouth City Council; 1951 – New Plymouth City Council, *Urban Land Use Map of New Plymouth*, Scale 1 inch to 5 chains, 1951, in New Plymouth City Council.

THE PUKERUA TECTONIC CORRIDOR, WELLINGTON

C. A. COTTON

THE PUKERUA tectonic corridor branches from a chain of downwarped basins (including the Port Nicholson and Porirua Harbour basins) in the Wellington district. Hill-bordered and flat-floored, this corridor extends northward from the Porirua Harbour basin to the shore of Cook Strait at Pukerua Bay (*Fig.* 1). Various geomorphic features of the corridor itself and of its flanking heights attract attention as rather uncommon examples of both tectonic and erosional landform development.

WELLINGTON TECTONIC RELIEF

Not only in the Wellington district but also widely throughout New Zealand the bedrock greywackes—though sedimentary and stratified rocks—must be regarded from the geomorphic point of view as massive and structureless. Thus in their case the idea of 'adjustment to structure' in the arrangement of drainage and the shaping of landforms must be set aside, at least in so far as adjustment might be controlled by the strike of stratified formations. An alternative that has been offered, though with limited success, to explain the landscape forms, is a theory of erosional adjustment to more or less parallel fault zones along which the greywacke rocks have been crushed, even pulverized, and thus thoroughly weakened. The evidence afforded by the shapes and attitudes of landforms themselves, however, supports the very different explanation that practically all the forms of relief in and around Wellington are of tectonic origin—except the fine-textured dissection due to the erosive activity of numerous small streams.[1] In brief, the origin of the relief is consequent on the deformed state of the surface instead of being erosional and circumdenudational and therefore subsequent; and this applies in particular to the elongated, more or less parallel ridges and the major valleys, which were formerly attributed to differential, or selective, erosion. Among features for which a tectonic origin seems obvious are the Pukerua corridor and the conspicuous ridge parallel to it on the west side.

The failure of the stratified greywackes to respond to prolonged

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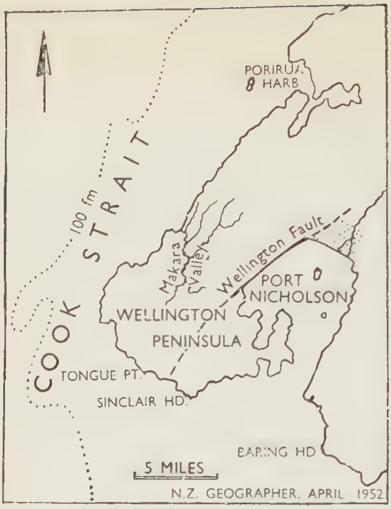
[1] C. A. Cotton: 'Tectonic Features in a Coastal Setting at Wellington', *Trans. Roy. Soc. N. Z.*, Vol. 82, 1957, pp. 761–90.



N.Z. GEOGRAPHER, APRIL 1952

Fig. 1. Locality map of the vicinity of Wellington

denudation after the manner of simply-folded sedimentary strata, calls for some explanation. Observation in the field of dips and strikes demonstrates clearly that the greywacke strata are not *simply* folded, even though a general north-northeasterly trend of the strike may be indicated. There are many local departures from this, and the structure is unquestionably complex. There are, indeed, outcrops of fairly thick strata or lenses of greywacke with few joints and therefore not weakened by very deep weathering; and such outcrops are generally at high levels on summits and ridge crests that owe their altitude at least in part to the resistance this fresh rock offers to denudation. These are, however, rather exceptional. Much more widely, strata exposed in sequence do not vary much in resistance. These rocks are jointed and shattered and, as a result rock materials that may originally have varied in resistance are weakened alike to a great depth by incipient weathering. A partial explanation is thus afforded of the behaviour of the greywackes when exposed to erosion; but the prime cause is a kneading together, accompanied by induration, that has affected the whole mass in a past age in the process of intense deformation. The greywacke terrain affords an example of 'post-orogenic cratonization'; once closely folded as an orogen, thick stratified formations assume the characteristics of a craton, or rigid mass, and thereafter behave like massive rocks.

Cratonization accounts also for the manner in which the greywackes yield to any new orogenic stress and thus it can be explained why they are deformed by faulting instead of by folding. Fault blocks produced by this process (many of them quite small) were the initial forms from which the existing Wellington landscape forms have been developed by erosional processes.

In explanation of the probable origin of stresses responsible for producing this jumble of small blocks it must be noted that a major fault cuts right through Wellington (*Fig.* 1); that this is at least in part, and perhaps dominantly, a fault with horizontal displacement (transcurrent);[2] and that drift along such faults, if the movement is on a sufficiently large scale, may well buckle the crust, such buckling being expressed in a cratonized terrain as block faulting.

The system of basins of which the Pukerua corridor is a branch may perhaps be said to be due to the same buckling (whatever its cause) that was responsible for the more numerous blocks which provide the minor relief features of the area. The largest basin, that concontaining the lake-like Port Nicholson, borders the great Wellington Fault, a likely place for major buckling. So, too, does its branch, or extension, the Hutt Valley. A corridor extends northward at a rather high level (through Johnsonville to Porirua) and expands into another broad basin that contains Porirua Harbour in its deepest part; and the chain of depressions is continued northward beyond this as the narrower Pukerua corridor.

A former peneplain, now a warped and fault-broken surface (the 'K-Surface'),[3] can be traced over high blocks as well as on slopes that lead down into warped basins; it is a key surface, the presence of which, though fragmentary (owing to the ravages of erosion), serves to define

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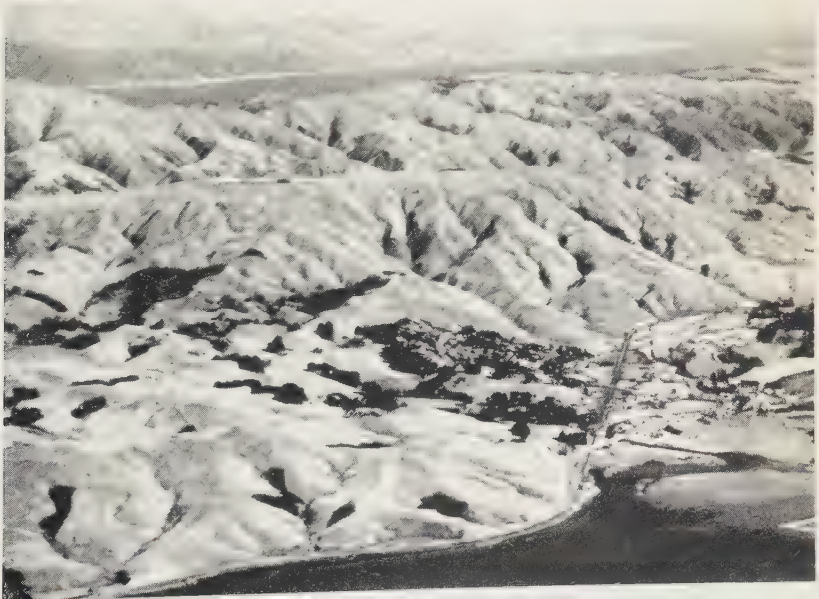
[2] C. A. Cotton: 'Fault Valleys and Shutter Ridges at Wellington', *N. Z. Geographer*, Vol. 7, 1951, pp. 62-8.

[3] Cotton, *loc. cit.* (1957), pp. 774-7

Fig. 2. The Wellington block-faulted landscape. In foreground, Porirua Harbour basin; in middle distance, Table Top block, with K-Surface on top; in distance, the Port Nicholson basin

Photo: Ministry of Works



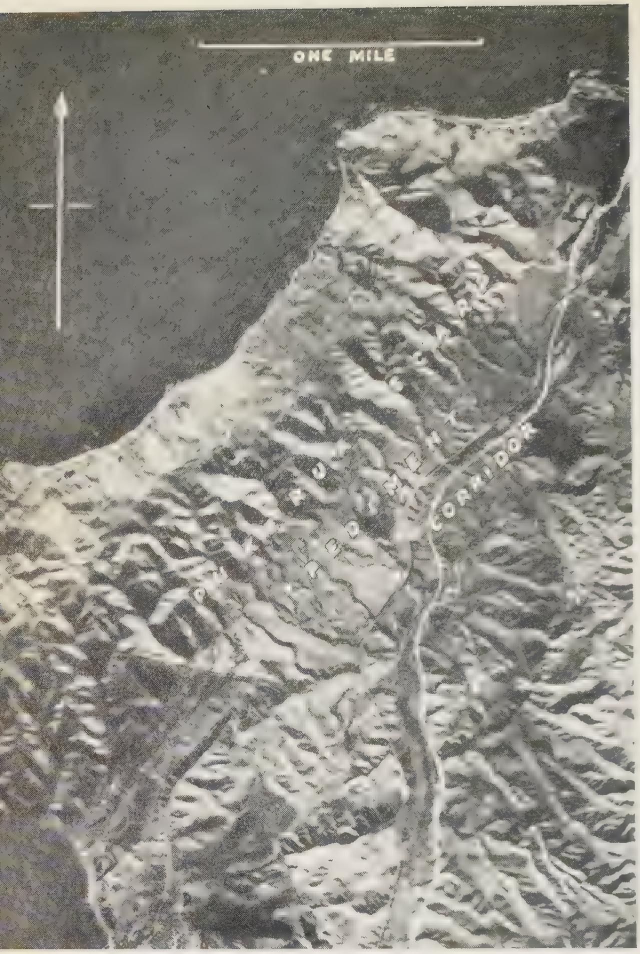


Fig. 3. Pukerua corridor and ridge

(*Figs.* 3 *and* 4 *are from N.Z. Air Mosaic WN 74:B39, Paraparaumu-Porirua No.* 2.)

the initial forms of blocks, basins, and tectonic corridors. A well preserved flat remnant is seen near Porirua on Table Top (*Fig*. 2) at about 900 feet; another conspicuous remnant forms the top of Mana Island (in Cook Strait) at about 450 feet; and on the floor of the Pukerua corridor the surface is present at about 300 feet (*Fig*. 3).

BORDERING FEATURES WEST OF THE CORRIDOR

West of and parallel to the Pukerua corridor is an upfaulted block, the Pukerua ridge (*Fig*. 3), the most interesting part of which is its eastern scarp. This may be merely a little-dissected fault scarp, towards the foot of which the K-Surface, at a low level, is slightly upwarped so as to resemble a pediment. More probably, however, this pediment-like form is not a part of the K-Surface but is a true pediment, though slightly dissected.[4] If this is so, the existing rectilinear scarp

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[4] Cotton, *loc. cit*. (1957), Figs. 3, 4.

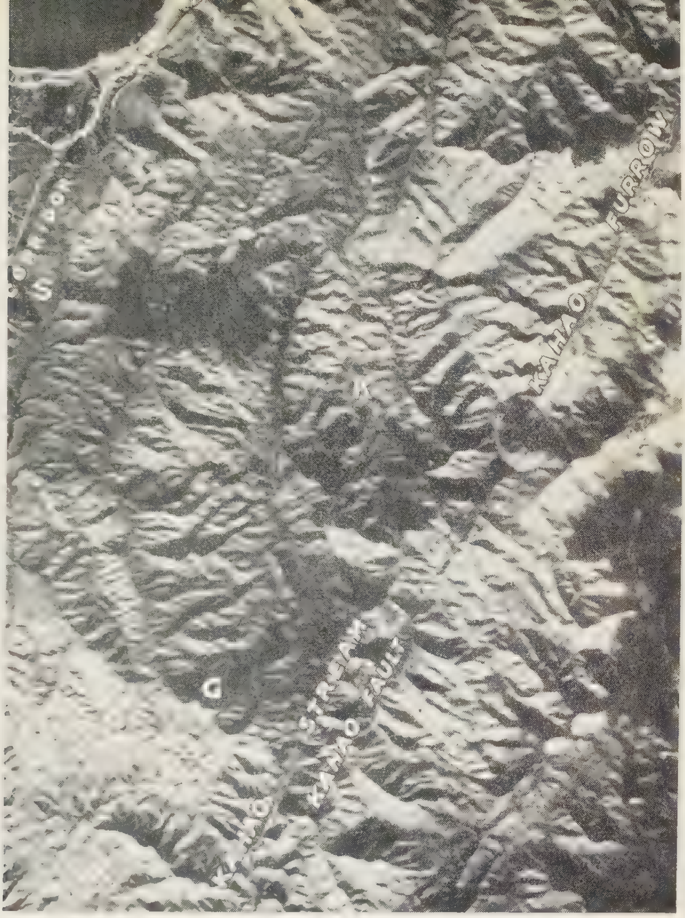

Fig. 4. Tectonic and erosional features east of the Pukerua corridor

G: antecedent gorge; K: K-Surface remnants; S: source of the largest western branch of the Kahao Stream

(*Fig.* 3) must have been 'backworn' from the initial fault scarp by a process of pedimentation.

The idea of a succession of changes of climate in the Pleistocene period being now generally accepted, it is not inconceivable that Wellington has passed through at least one phase of warmth combined with semi-aridity. Such conditions favour rapid pedimentation. Two suggestions as to the date of this have been made:[5] (1) End-Pliocene, or Villafranchian, an age in which extensive pediplanation took place in Brazil, Spain and Portugal (perhaps too ancient for the stage of geomorphic development and preservation of the Pukerua landforms); (2) some part of the Mindel-Riss (Yarmouthian) interglacial age, which is generally regarded as of very long duration, perhaps even 300,000 years,[6] and as having a climate for the most part warm and, in some regions, with a tendency towards aridity.[7]

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[5] Cotton, *loc. cit.*, (1957), p. 789.

[6] R. F. Flint: *Glacial Geology and the Pleistocene Epoch*, New York, Wiley, 1947, p. 282.

[7] J. C. Frye and A. B. Leonard: 'Ecological Interpretation of Pliocene and Pleistocene Stratigraphy in the Great Plains Region', *Amer. Jour. Sci.*, Vol. 255, pp. 1-11.

The pedimentation hypothesis is strongly supported by the fact that it explains southwestward right-angle turns made by streams that dissect, and flow from, the Pukerua scarp near its southwest end, thus taking short cuts to the sea (*Fig.* 3). These streams, like all the others flowing from the scarp farther northeast, seem to have taken part in the carving of the pediment by lateral planation, developing in this process confluent rock fans with only a thin gravel cover such as is still present on doabs of the pediment (or pseudo-pediment). While pedimentation was in progress the streams would necessarily change courses from time to time, running down the fan radii one after another. But rejuvenation (if it took place) would confine a stream thereafter to a particular radius. Those at the southwest end of the scarp would seem, when flowing down southwesterly radii, to have become entrenched, quite probably as a result of marine cliff recession. Spilling from radius to radius, they would be caught by such rejuvenation and fixed in place if marine erosion bit into the southern edge of the pediment (*Fig.* 5).

Features East of the Corridor

The K-Surface (*Fig.* 4, K) rises from the corridor eastward on the back slope of a tilted block four miles wide, from which a much-dissected fault scarp leads down to the Horokiwi Valley tectonic depression. (This is east of the area shown in *Fig.* 4, but it is shown in *Fig.* 6.) Relics of the K-Surface define the shape of the initial block, now much

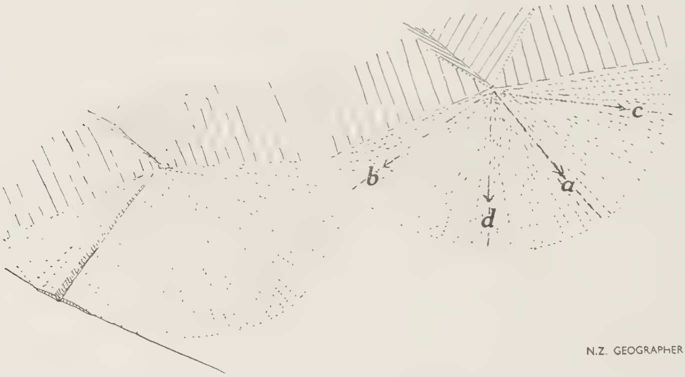

Fig. 5. Fixation of a stream course across a fan. On any fan, whether alluvial or rock, widely spaced radii such as *a*, *b*, *c*, *d*, will be occupied successively and repeatedly as courses by the fan-building (or fan-cutting) stream, though not always in the same order. Should the margin of the fan become cliffed, as shown at left, the stream, when eventually it spills down a radius that leads it over the cliff, becomes entrenched and is confined thereafter to a fixed course dissected. The surface has not been smooth initially, but has been broken apparently by a fault, for it is now traversed by a remarkably straight and narrow furrow with a north-northeast trend (*Fig.* 4, 'Kahao furrow'), which is occupied by reaches of different streams and branch streams, some flowing north-northeast and others south-southwest in V-section valleys. This furrow is on the line of the Kahao Fault, which farther south is not *in* but *parallel to* the axis of the valley of the Kahao Stream (*Fig.* 4). Along this (southern) part of the surface trace of the fault there is also a furrow across the landscape (*Fig.* 6).

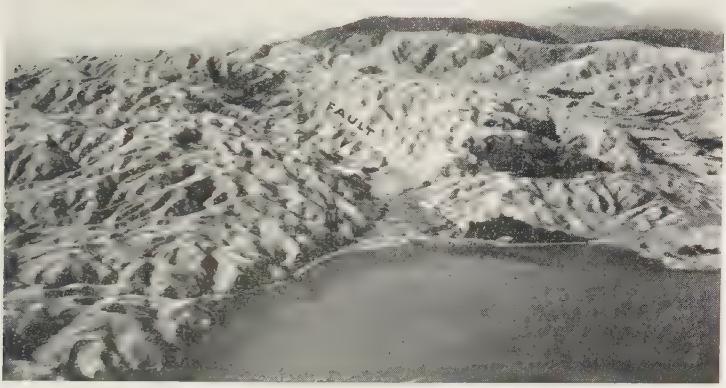

Photo: Ministry of Works

Fig. 6. Dissected tilted block east of the Pukerua corridor, bisected by the Kahao Fault. At the right is the Horokiwi tectonic valley; at the left are tilted remnants of K-Surface separated by the antecedent gorge of the western Kahao

Though here it is not deep enough to be followed by continuous streams, it crosses (in strictly aligned notches) numerous spurs that lead down into the valley of the Kahao. Offsetting of the spurs and of small Kahao tributaries seems to indicate some rather recent horizontal (transcurrent) movement along the fault. Striking as this is, it is no more remarkable than the alignment of the multi-stream deep furrow on the trace of the same fault farther north.

If the hypothesis is rejected of development of aligned stream courses by headward erosion of individual small streams along a zone of fault-crushed rock,[8] it may be suggested instead that a fault with a *small* throw on this line has made a fault angle at an early stage of deformation;[9] that consequent streams have followed this shallow fault angle;

Cotton, *loc. cit.* (1957), p. 784.

Cotton, *loc. cit.* (1957), Fig. 10.

and that some later uplift has stimulated the streams to incise the rather deep V-section valleys in which they now flow.

Still another remarkable feature testifies to the tilting that accompanied upheaval of the block east of the corridor. Streams have their sources on the floor of the corridor at about 300 feet altitude (*Fig.* 4,S) and flow southeastward, entering gorges (G) and emerging from these as branches of the Kahao Stream. It seems impossible that streams such as these should flow through gorges (one of them 600 feet deep) unless they had taken their courses before the uptilted block rose under them, though slowly so that they were able to maintain their courses as antecedents, thus incising the gorges as the block rose.

CHARTING BANKS PENINSULA: 1770—1850

PETER B. MALING

THE story of the charting of Banks Peninsula and the adjacent coast of Canterbury begins with Captain James Cook in 1770. Tasman, in 1642, saw no part of the east coast of New Zealand. Those who claim that this coast was known to the Portuguese still earlier base their assumption on the evidence of the 'Dieppe maps' drawn by French cartographers between 1530 and 1550, who appear to have derived their information from Portuguese sources. The significance of their southwest Pacific land outlines has been much debated. It has been contended that these maps depict the northern half of the coast of Australia and part of the east coast of New Zealand. For instance, in the chart of the southern hemisphere by Jean Rotz (1542) the bold cape (marked as 'Cabo Fremose' on Descelliers' world map of 1546) has been taken to represent East Cape of the North Island of New Zealand. The deep gulf to the south of this ('Baie Grande' of Descelliers) has been considered to indicate Cook Strait.

There is an interesting reference in 'A Chart of the Indian Ocean Improved from the Chart of M. D'Après de Mannevillette; with the Addition of a Part of the Pacific Ocean . . . .', by L. S. de la Rochette, published in London by W. Faden in 1803. This chart bears the legend, 'New Zeeland, discovered and named by Tasman, 1642, but whose Eastern Coast was known to the Portuguese about the year 1550.' It also marks 'Cape East, 1769 (Cabo Fermoso, 1550)', and against Cook Strait it records 'Gulf of the Portuguese, 1550.' These annotations were repeated in later editions of this chart published in 1817 and 1827. Probably de la Rochette derived his information from one of the Dieppe maps, the 'Dauphin', which had been presented to the British Museum by Sir Joseph Banks in 1790. Before this, these maps do not appear to have been known to cartographers.[1]

Other than the dredging-up of a Spanish type of helmet from the mud of Wellington Harbour, and the finding of a ship's bell, with a Tamil inscription, in the possession of Maoris in the interior of the North Island in 1836, there is no evidence available to support the theory that the Portuguese visited the shores of New Zealand in the sixteenth century. We presume therefore that the story of the charting of the east coast begins with Cook.

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[1] J. C. Beaglehole: *The Voyage of the Endeavour*, 1955, p. 160.

Cook's admirable chart of the South Island contains two well-known errors. Banks Peninsula was charted as an island, and Stewart Island was joined to the mainland. But, whereas at least some of the *Endeavour's* officers disagreed with the latter, none of them seem to have had any doubts as to the insularity of the hilly oval of land constituting Banks Peninsula. Cook himself wrote, on February 17, 1770: 'At sun rise, being very clear, we plainly discoverd that the last mentioned land was an island. . . .'[2]

Chase's Discovery

For the next forty-five years Cook's outline for the east coast of the South Island of New Zealand was used on every chart of this part of the Pacific. It was not until sealers had been on the southern coasts of New Zealand for some fifteen years that we have any record of a ship sailing along the South Island's east coast. In 1809 the *Pegasus*, with Chase in command and William Stewart as first mate, left Hobart Town to seal in southern New Zealand waters, and thence direct to England. Leaving Stewart Island, Chase appears to have sailed along the east coast, but the only record of this available is a note in *The Oriental Navigator* of 1816. Here we read (p. 91) that 'the ship *Pegasus* advancing from the northward to pass through this supposed channel (between Banks Island and the mainland) fortunately discovered, before night came on, that the island, so called, is really connected with the mainland by a low isthmus, in approaching which they had soundings of 15 and 14 fathoms.' As a result of this observation the bay to the north of the peninsula became 'Pegasus Bay or Cook's Mistake', and later plain 'Pegasus Bay'.

The first chart known to incorporate Chase's information is a plate entitled 'Océanie, ou Australasie et Polynesie' in Lapie's world atlas of 1816. This shows 'Presqu'île de Banks', but Stewart Island remains connected to the mainland as in all the earlier charts. The 1817 edition of L. S. de la Rochette's blue back chart, published by Faden and referred to above, is the first British chart known to figure 'Banks Peninsula', and this also has Stewart Island correctly shown.

Purdy's *Oriental Navigator* of 1816, a volume of sailing directions,

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[2] *ibid.*, p. 253.

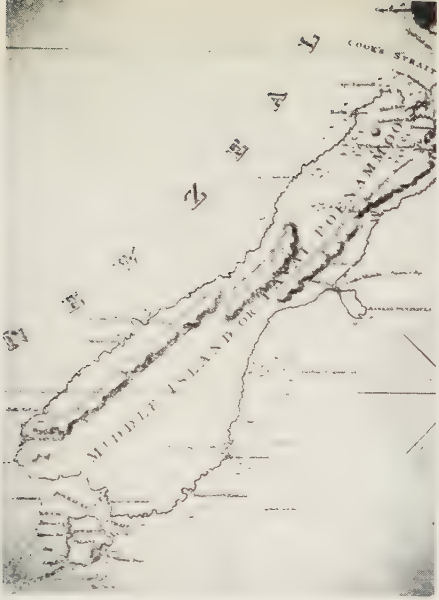

Fig. 1. Detail from J. W. Norie's Chart of part of the Pacific Ocean, published in 1820 with additions to 1827

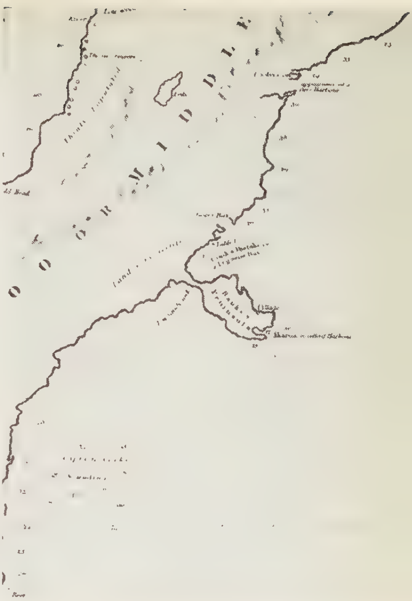

Fig. 2. Detail from a chart of New Zealand by Thomas MacDonnell, published by James Wyld, London 1834

was complementary to a large marine atlas by J. W. Norie & Co., entitled *The complete East India Pilot, from London to any part of the Indian & China seas* . . . . This was an important atlas of blue back charts, probably the best marine atlas of its time, and it went through five new editions between 1816 and 1827. The chart of the Indian and Pacific Oceans which appears in the first edition (1816) was drawn by William Heather in 1806 and follows Cook's outline for the coast of Canterbury. The 1820 edition contained 'A New Chart of part of The Pacific Ocean . . . . between the Latitudes of 48° South and 22° North, and from the Longitude of 141° to 180° East'. This, at the time, was the best chart of New Zealand available to mariners. Copies of this edition of Norie's atlas are now very rare. Banks Peninsula appears in the 1827 edition of this chart as a roughly rectangular mass attached to the mainland by a 'low sandy neck' (*Fig.* 1). It remains thus in later editions until in that of 1845 it has become simply a 'sandy neck' and has widened slightly.

Of other charts published between 1815 and 1820 it is surprising how many failed to incorporate Chase's discovery. For instance a chart of New Zealand, published under the auspices of the British Hydrographic Office by Captain Hurd, R.N., in 1816, shows 'Banks Island'. The chart illustrating J. L. Nicholas's *Narrative of a Voyage to New Zealand*, published in 1817, is no better. From 1820 until 1845 most cartographers followed J. W. Norie and drew the peninsula with a narrow isthmus (*Fig.* 2). This myth must have been dispelled by whalers who frequented Banks Peninsula from the early 1830's, by the French who settled at Akaroa in 1840, and certainly by Messrs Daniell and Duppa who were sent by the New Zealand Company in 1841 to report on the suitability of Port Cooper (later Lyttelton) and the adjacent country for settlement. However it was Dumont d'Urville's expedition in the *Astrolabe* and *Zélée* which sailed up the east coast of the South Island in March and April of 1840 that first charted Banks Peninsula in its nearly correct form. The chart of this voyage was the work of Vincendon-Dumoulin assisted by the officers of both corvettes. It was published in d'Urville's account of the expedition, and by the French Hydrographic Office. It bears the number 1088 and the title 'Carte de la Partie Orientale des Iles Tavaï-Pounamou et Stewart', and has an interesting inset of Peraki Harbour, Hempleman's whaling station on the south side of the peninsula.

Recording the Inlets

A large manuscript map drawn by C. H. Kettle in 1843 incorporated Daniell's and Duppa's observations, and those of Mein Smith who visited the area in 1842. Kettle was stationed in Wellington as chief surveyor to the New Zealand Company, and had not himself visited the east coast of the South Island. This perhaps accounts for the odd, elongated shape which he gives to the peninsula. This map is preserved in the Public Records Office, London, and is of particular interest as it bears the legend, '. . . Port Cooper, the intended site of New Edinburgh.'

By 1838, Banks Peninsula was frequented by numerous British, French and American whaling ships. These however left few records and no charts. It is to a French naval corvette which came south from the Bay of Islands to look after the interest of its country's whalers that we owe the first detailed charts of the harbours of the peninsula. This was the *Héroine* with Captain Cécille in command. The corvette arrived at Akaroa in June 1838 and later visited Port Cooper and anchored in Little Port Cooper, the first bay within the heads on the south side of the harbour and much used by whaling ships of the day. One of the whalers in the bay at the time was Langlois in the *Cachalot*. He was negotiating a deal with the Maoris for a large portion of the peninsula, and with visions of establishing a French colony he may have persuaded Cécille to carry out surveys of the main harbours.

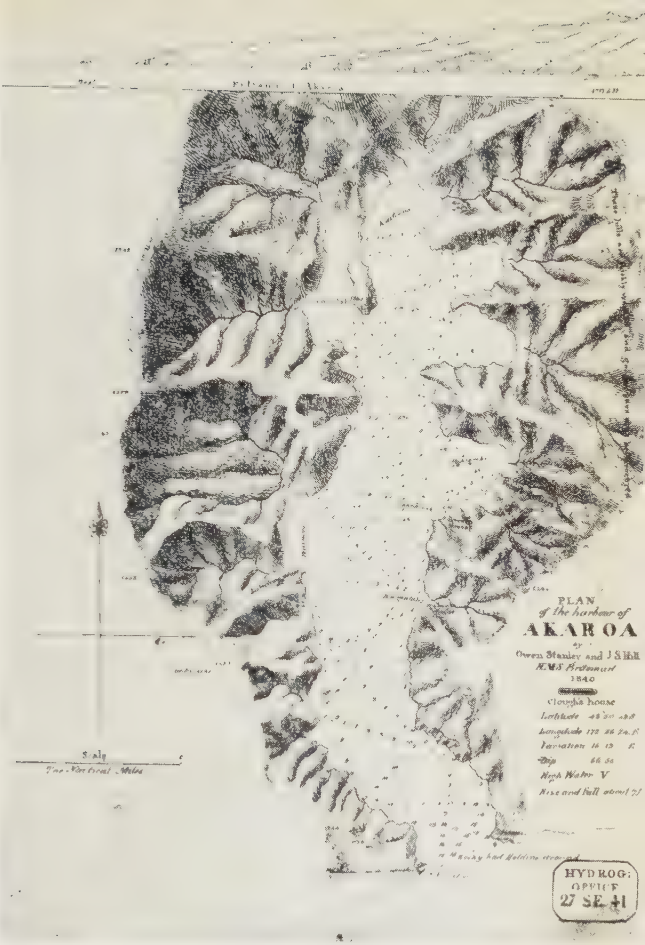

Fig. 3. Manuscript chart of Akaroa Harbour by Captain Stanley and Lieutenant Hill of the *Britomart*, 1840

(By courtesy of the Hydrographer of the Navy)

In any case, during the *Héroine's* visit, Lieutenant Fournier prepared a detailed chart of Ports Cooper and Levy. This manuscript is in the archives of the Depôt de la Marine, Paris, and bears the title, 'Plan du Port de Tokolabo (Nlle. Zélande)' and includes two inset sketches. These are the earliest recorded sketches of any part of Banks Peninsula and show the entrances to Port Cooper and Pigeon Bay. The official published version of this chart (No. 910) appeared in 1840 and in the legend Fournier's name is coupled with that of Midshipman d'Ubraye. The same two were responsible for the first chart of Akaroa harbour. On their manuscript the legend 'Plan du Port d'Akaroa' is amended in pencil to read 'Plan du Port Louis Philippe, ancienne Baie Akaroa . . .' But this does not appear in the official printed version of 1840 (No. 909). The latter has an inset sketch of Akaroa heads which does not appear on the manuscript noted.

In August 1840, Captain Owen Stanley and Lieutenant J. S. Hill of H.M.S. *Britomart* prepared excellent charts of Akaroa and Pigeon Bays. That of Akaroa was published later by the Admiralty (L.1575). No further charting was carried out by British ships in this region during the next eight years, but the French were active. The settlement at Akaroa necessitated a corvette being stationed there to look after the interests of the French settlers. First there was the *Aube* with Lavaud in command, and then the *Rhin* with Bérard. Lavaud produced a very fine chart of Akaroa in 1841 which has never been published by the French authorities. Bérard and his officers drew up a map of the entire peninsula, incorporating Lavaud's work. Charles Meryon, the artist, was an officer in the *Rhin* at the time and assisted with the preparation of this map which was the first to be printed dealing with the peninsula alone. Entitled 'Carte de la Presqu'île de Banks' it was published in Paris in 1848. As a piece of fine engraving, it is magnificent; but it is not very accurate, and it would appear that the officers of the *Rhin* did very little survey work on land.

There follow the first 'Canterbury Pilgrims', the three surveyors and their five survey-hands who arrived in Port Cooper in December 1848, and who, in the course of two months, made a preliminary reconnaissance of the country lying between the Waipara River in the north and the Ashburton River in the south. On behalf of the Canterbury Association they drew up a 'Sketch Map of the country intended for the settlement of Canterbury.' Signed by J. Thomas, the Principal Surveyor, the map, which included the whole of Banks Peninsula, was drawn by C. O. Torlesse. The third surveyor, T. Cass, made a detailed survey of Port Cooper, but no copy of his chart has been found. This Canterbury Association map and those prepared by Captain J. Lort Stokes and the officers of the survey ship H.M.S. *Acheron*, in 1849–50, mark a turning point in the story of the charting of this region. The outlines and much of the detail were now accurately recorded for the first time.

NEW ZEALAND RAILWAY TRAFFIC PATTERNS

WILLIAM H. WALLACE

TRAFFIC on the New Zealand Government Railways varies from place to place and reflects areal differences in settlement and economy. The varied pattern of traffic, the relationships between rail activity and the character of the areas served, and the interregional flows of goods and people reflect much of the geography of New Zealand. This is particularly true because of the dominant role which railways play in the carriage of goods. Since World War II, they have carried approximately five times the tonnage handled by coastal shipping. Competition from road haulage is severely restricted by law, for where rail service is available trucks are limited to hauls of thirty miles or less.[1] The significance of the government railways is enhanced by the fact that they comprise virtually the entire 'common-carrier' railnet, into which the few, short, private railway lines feed timber, coal and other bulky goods.

The role of railways in passenger carriage is less important. Motor vehicles, including taxis and rental cars, are the most common means of passenger transportation. Buses are most important for short and intermediate distances—back and forth between each of the four main centres and lesser towns, and within the suburban areas, whereas railways play their most important role between the largest cities on each island and in one or two suburban areas. Ships are important only for interisland journeys, but they are being strongly challenged by air carriers which play an increasingly important role in long distance travel between the major cities.

EXTENT OF TRAFFIC

Attention is here concentrated upon the pattern of railway traffic density. Average densities (expressed in gross long ton-miles of all types of traffic per route-mile of line) have been calculated for major segments of the railnet, and, where these segments are long, may conceal local variation from the average. On most lines there is a steady increase in density toward the major traffic foci, and this pattern (or departures from it) is analysed and interpreted. Data used are for the New Zealand fiscal year from April 1, 1952 to March 31, 1953. This is considered a satisfactory example of 'contemporary' conditions because it was free from major economic, political and social disturbance and rail traffic resembled that of earlier and later years.

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[1] Exception is made in the case of certain types of livestock which are permitted longer road hauls in competition with rail services.

The route mileage during the year 1952–3 was a mere four miles short of the all-time maximum established the previous fiscal year. The period of rapid railnet expansion in New Zealand is now definitely over; indeed the trend toward reduced rail mileage that began during 1952–3 has continued. Some branch lines in operation during the period analysed have since been abandoned, though there have, it is true, been some additions.

INTENSITY OF TRAFFIC

During the year under study, the average traffic density on the railways system was 1,059,952 gross ton-miles per route-mile of line. The comparable figure for the entire railnet of the United States was 6,441,290. Of American 'Class I' railways,[2] only the Rutland railroad, almost entirely within the rural state of Vermont, had a traffic density similar to that of New Zealand: all others had considerably greater densities. In terms of net ton-miles of *freight* hauled, traffic on New Zealand railways is comparable with that of Australia, Argentina, Denmark, Norway, Taiwan and the Sudan, and is significantly heavier than that of most of the railways of Latin America, the Orient, and central Africa. However, densities on the railnets of Anglo-America, northwestern Europe and areas of the East and Africa where mining and manufacturing are important are from two to twenty times heavier than in New Zealand.

INTER-ISLAND CONTRASTS

The general intensity of activity is considerably greater in the North Island than in the South. Average North Island traffic density (1,492,184 gtm/rm)[3] is more than twice that of the South Island (663,485 gtm/rm). Indeed, the volume of traffic which moved over the North

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[2] In the United States a Class I railway is a system that has annual gross revenues of three million dollars or more.

[3] Figures in brackets throughout this article indicate traffic densities in thousands of gross ton-miles per route-mile of line during the year ending 31 March, 1953.

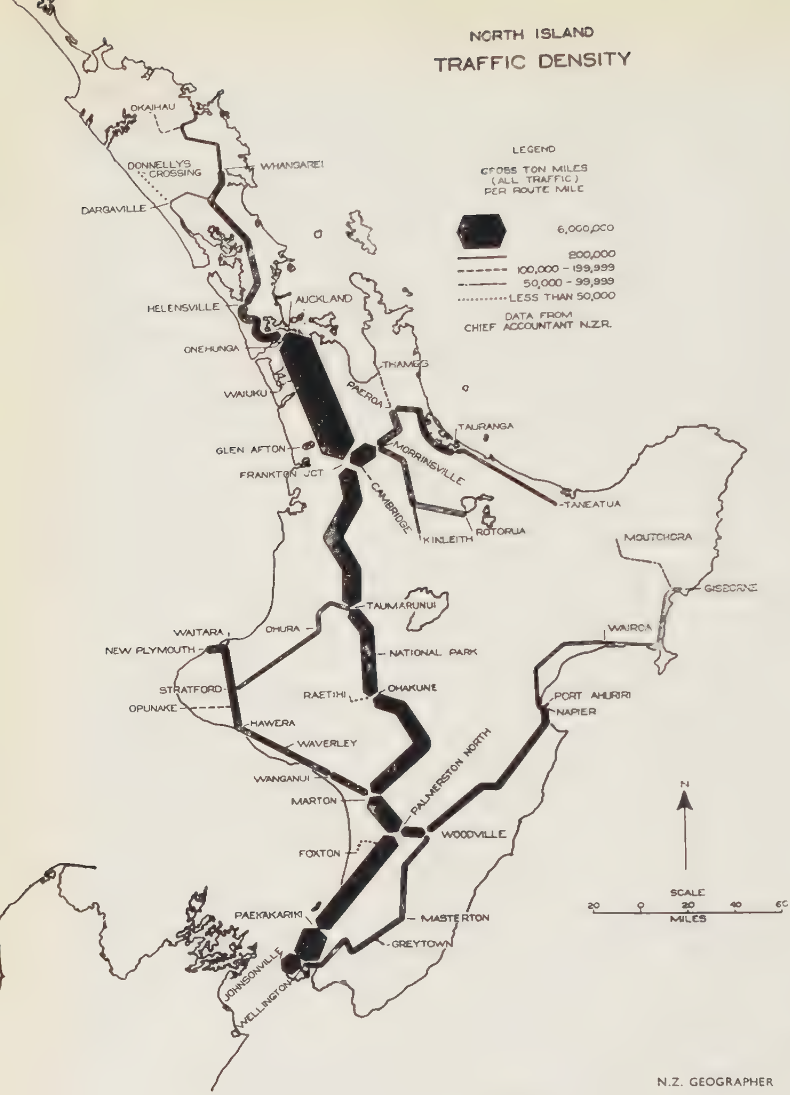
Island Main Trunk alone was equal to 125 percent of the total traffic on all South Island railways—a contrast accentuated by the fact that twenty-seven percent (450 miles) of the northern mileage had traffic densities of more than 2,000,000 gtm/rm, whereas only six per cent (110 miles) of the southern railnet had such high densities. Only eight percent (134 miles) of the North Island mileage was composed of light traffic branches (with densities less than 100,000 gtm/rm), whilst fully twenty-nine percent (539 miles) of the South Island railnet was made up of such light traffic lines.

In 1952–3, the New Zealand railway system was composed of three physically separate units—the North Island railnet, the South Island railnet and the Nelson line (*Figs.* 1 and 2). Although each had terminals in one or more ports, no train ferry services, such as those of Japan, were operated, and there was no direct interchange between the three sections. Goods originating on one railway and destined for a station on another had to be unloaded at ports or railheads for transfer to other carriers from which they were reloaded into railway cars for movement to their ultimate destination. This threefold physical division was complemented by four major functional divisions, each focused upon one of the four main centres and characterised by a general increase in traffic density towards that centre, and separated from the neighbouring system by a low traffic density col.

The railways of the North Island form a unified system, the two major divisions of which are linked by the North Island Main Trunk line and the Stratford-Main Trunk line, which tie together the 'regional' railnets. These functional divisions are however separated by low traffic density cols near National Park and Ohura, north of which the basic function is to link the country to Auckland, and south of which rail activity focuses on Wellington.

North Auckland

The railnet for which Auckland is the focal point consists of two major parts. The northernmost, in Northland, is made up of one dead-end main line and two branches. The basic feature is a general increase in density towards Auckland, indicating that the primary function is to link Northland with New Zealand's largest trade centre and port. Nowhere is traffic extremely heavy, but on only one section of branch line is traffic density very low. This reflects the moderate level of economic activity and the medium density of population within the



N.Z. GEOGRAPHER

Fig. 1. Traffic density on North Island railways for the year ending March 1953

hinterland of the railways as well as a location in the New Zealand railnet which eliminates the possibility of bridge traffic.[4]

The North Auckland line is a dead-end main line linking Whangarei with a number of lesser towns and the principal intensive pastoral farming districts of Northland, and tying the region to Auckland and the rest of the North Island. Traffic density at the isolated northern extremity with its little-developed hinterland is very low for a main line. The steady southward increase indicates a focusing of traffic on Auckland and a greater intensity of human activity, whilst near the

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Bridge traffic, or overhead traffic, is that which neither originates nor terminates on the section of line under consideration.

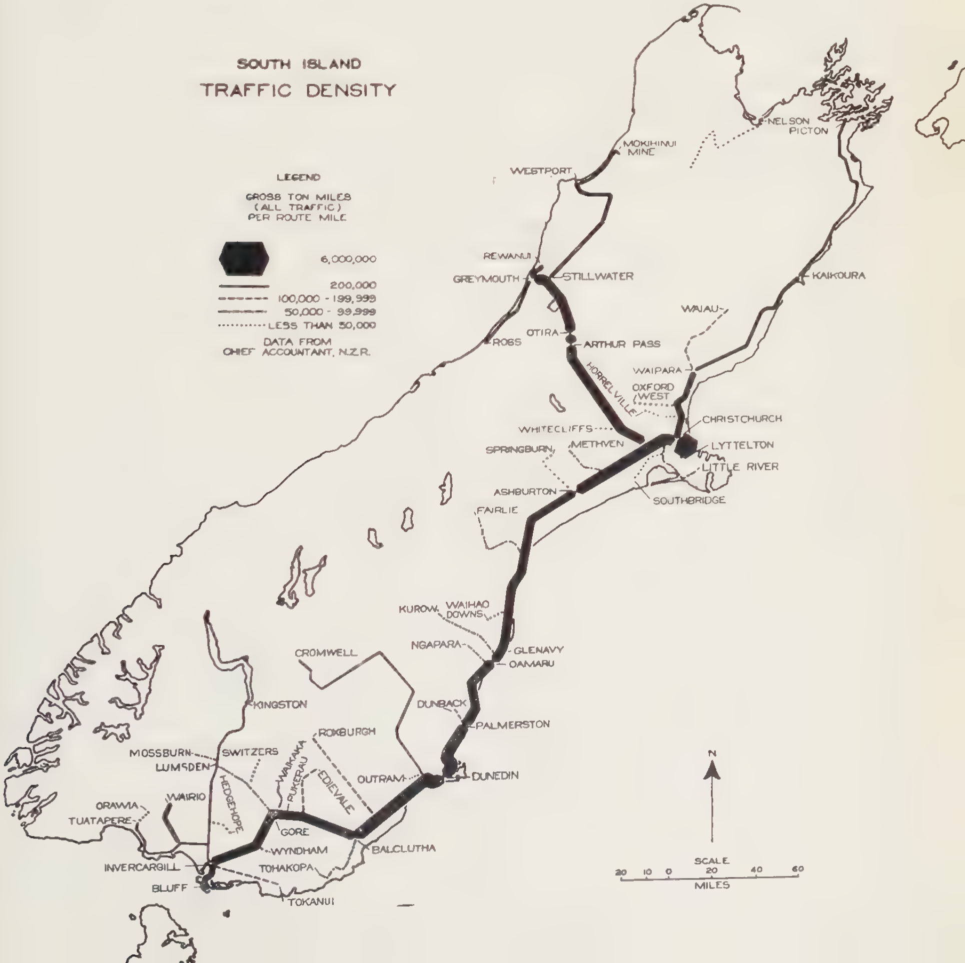
city suburban passenger trains and urban demands produce the maximum traffic density (1518) on the line.

The two branch lines have basically similar functions: both link secondary trade centres and nodes of intensive pastoral farming with the North Auckland line. Traffic densities on the Okaihau (189) and Dargaville (216) lines are relatively heavy for branch lines, varying roughly with the populations and commercial importance of the towns they serve. The section that connects Dargaville with Donnellys Crossing, however, has a relatively unpopulated hinterland where small-scale timber cutting is the major activity; consequently it has the second lightest traffic density (40) in the North Island.

SOUTH AUCKLAND

The railways of South Auckland consist of two trunk lines, two dead-end main lines and six branches (*Fig.* 1). The general pattern is

Fig. 2. Traffic density on South Island railways for the year ending March 1953



characterised by an increase in density towards the North Island Main Trunk and, on that line, towards Auckland. This pattern reveals that the basic link is with Auckland and that connections with the rest of the North Island are of secondary importance. Traffic density is very high on a large part of the main line and none of the South Auckland branches has a very low traffic density.This high level is in keeping with population density, economic activity and, on the two trunk lines with extra-regional connections, it reflects important bridge traffic.

Of three of the four main lines which tie the Volcanic Plateau, the King Country and the Waikato-Hauraki Plains to Auckland, the North Island Main Trunk is the basic member. It links the heart of the area with the city, 'funnelling' the traffic of all other South Auckland lines to and from Auckland, and providing the principal link with other portions of the North Island system.

Traffic density is least where the line runs past the timber mills and through the extensive pastoral farms and wastelands of the south; and rail activity increases steadily (2445; 2947; 6038) towards Auckland where its density is far higher than anywhere else in New Zealand. Increments occur in the populous and productive farming districts north of Te Kuiti, in the nearby lime-extracting areas, and more conspicuously, in the Waikato coalfields around Huntly. Traffic is funnelled to and from the three branches which diverge north of Frankton Junction, the Stratford-Main Trunk line, and, most importantly, for the Bay of Plenty line. Near Auckland, suburban passenger trains and industrial establishments make additional heavy contributions.

Lines to East and West

The main line to Taneatua connects the productive agricultural districts along the shores of the Bay of Plenty and those on the Waikato-Hauraki Plains with the North Island Main Trunk line. It now also taps the timber trade of the Murupara-Kawerau district. In 1952–3, the eastern end had a traffic density which is very low for a main line (527) but further west, where the line traverses a more productive and populous hinterland and carries more cumulative traffic, density increased sharply (897; 1267). West of Morrinsville, where the line 'funnels' traffic of the Rotorua line and, in lesser volume, of the Cambridge and Thames branches, density (3044) actually exceeds that of the adjacent portion of the Main Trunk.

The Rotorua line passes through intensive pastoral farming districts on the eastern part of the Waikato-Hauraki Plains, terminates in a trade centre serving the forestry and rapidly-developing pastoral activities of the Volcanic Plateau and links these with Auckland and elsewhere. Here again, a general northward increase in density (averaging 1034) reflects cumulative traffic and greater hinterland productivity, and 'funnel' traffic to and from the busy Kinleith branch which makes a considerable contribution to the northern part of the line.

The Stratford-Main Trunk line links the railnets of South Auckland and Taranaki. The northern portion carries traffic of relatively low density (663)—largely overhead movements and coal shipped from depots near Ohura.

Three of the South Auckland branch lines link the minor trade centres of highly productive agricultural districts with main lines. Traffic on the Waiuku (80) and Cambridge branches (167), while reflecting the commercial significance of the terminal towns, is closely related to agricultural activity. The Thames branch (82) is more intimately connected with the industrial functions of Thames itself.

Two other branches carry much heavier traffic based on extractive activity. Heavy coal shipments give the Glen Afton branch one of the highest branch-line densities (1172) in New Zealand. The Kinleith branch (374) serves a major timber-extracting area and, during the year under consideration, it also handled much material used in the construction of a pulp and paper manufacturing plant.

The short Onehunga branch is essentially an industrial line and its relatively high density traffic (297) reflects manufacturing activity and the revival of Onehunga's function as a port.

Wellington - Manawatu

South of the low density cols near National Park and Ohura rail traffic focuses on Wellington forming a rail complex with three major divisions: Wellington-Manawatu, the heart of the railnet; the western extension to Taranaki; and the eastern extensions to Eastland.

The railways of Wellington-Manawatu, including all lines south of Waverley, National Park and Masterton, and west of Palmerston North, are composed of an axial trunk line, an additional trunk line providing connections with the west, one dead-end main line, and seven branches. The pattern of traffic density reveals the basic connection with Wellington: secondary functions include the link with the Auckland system and bridge traffic. Main line densities are high; branch line densities range from very low to extremely high, again reflecting population and economy.

The section of the Main Trunk line which lies south of National Park is the basic member of the Wellington-Manawatu railnet. It ties the upland interior of the North Island and the Manawatu Plain to Wellington, and is the trunk from which all other lines diverge. Traffic densities are lowest (2445) on the fringe of the Volcanic Plateau where the railway traverses a sparsely-peopled area with little agriculture, where timber cutting is primary, and where the paucity of local traffic gives bridge movements a greater relative importance than elsewhere on the Main Trunk.

Traffic Increase towards Wellington

Traffic densities increase southward as pastoral farming and population increase. Location relative to other parts of the railnet is another major factor in explaining traffic densities. Local position thus gives the Marton-Palmerston North segment a higher density (3271) than sections to the north (2608) or south (3141) for the Wellington traffic of the New Plymouth line and the Auckland and Taranaki traffic of the East Coast Main Trunk are 'funnelled' over this section. South of Paekakariki, traffic is again very heavy (4646), the increment being due primarily to the movements of large numbers of suburban passenger trains over this electrified section and to the urbanisation of the surrounding area.

That portion of the New Plymouth line which lies southeast of the traffic col near Waverley is considered to be part of the Wellington-Manawatu railnet because, primarily, it ties the coastal dairy-farming area with the Main Trunk line and with Wellington; distinctly secondary is the connection between Taranaki and southern or eastern parts of the island. Traffic density is moderately low (950) northwest of Wanganui, where the intensively-farmed pastoral belt is narrow, and increases towards Marton, the junction with the Main Trunk. Higher density (1149) southeast of Wanganui is associated with the broader extent of productive land, the commerce and industry of this city and its connections with the south and east.

Although the Wairarapa line connects with main lines at both Wellington and Woodville, not until recently did it function as a trunk line. In November 1955, the Rimutaka tunnel and the connecting 'low-gradient' line through the Rimutaka Ranges were opened, making it possible to handle much greater traffic over the southern section of the Wairarapa line than was possible during the year analysed. As a result, that line now handles a great deal of Eastland's traffic which was formerly sent via the Main Trunk line and Palmerston North. The average traffic density on the Wairarapa line is now approximately twice as heavy as it was four years ago, and this railway now functions as a trunk line.

In 1952–3, however, traffic centred on Wellington and Woodville and there was a strong divide near Masterton. Although the Wairarapa line was treated as a single statistical unit with a moderately low traffic density (880), there was a general increase in traffic southward from Masterton. Density is greatest south of Upper Hutt where the line—elsewhere traversing market towns and intensive pastoral farming districts—is crowded with suburban passenger and local freight trains serving a large population and numerous industries.

Traffic Varies on Branch Lines

Two of the six branch lines of this system join minor towns in rich farmland districts to the main lines. On both the Raetihi (density 42) and Greytown (53) lines, traffic is light, even for branches.

The Foxton branch, though on a productive plain, has, paradoxically, the lowest traffic density (32) of any North Island railway, for not only is its indirect route to Wellington exposed to Main Trunk competition, but its terminal town has a small hinterland and a peripheral location. Forming a strong contrast with these light-traffic branches is the Johnsonville line which provides frequent electric suburban train service for part of the Wellington metropolitan area and has a traffic density (3371) far heavier than any other branch line in New Zealand. Traffic data are not available for the other two branches—one a short industrial line in the lower Hutt Valley carrying traffic of moderate density, the other reaching northward from Petone through the Hutt Valley dormitory towns to Taita and moving a high density suburban passenger traffic.

Taranaki

The railways of Taranaki include all lines west of Ohura and Waverley, and consist of two sections of trunk lines and two branches. The general increase in traffic density towards New Plymouth, and the heavy traffic to and from the south via the New Plymouth line, reveal a dual function. This is to tie the Taranaki area to its regional centre and to provide connections elsewhere, primarily over the New Plymouth line, secondarily along the Stratford-Main Trunk line.

Of the trunk lines, the New Plymouth line is basic. It links the minor trade centres with New Plymouth, 'funnels' the traffic of all other Taranaki lines to and from this city, and provides a vital connection with the south. Traffic density is rather low (950) southeast of Hawera, but increases (1243) as the railway leaves the narrow littoral, nears the regional focus, passes through the market towns of the lowlands, and 'funnels' the traffic of three tributary lines. The Stratford-Main Trunk line provides a direct link with South Auckland and ties the extractive activities and extensive pastoral farms of Inland Taranaki to New Plymouth. Primarily, it handles bridge movements between Taranaki and South Auckland; consequently its traffic density varies but little and is, for a trunk line, low (663).

Both branch lines serve minor trade centres on the Taranaki lowlands. Modest traffic (109) on the Opunake branch is related to the commerce of its terminal town and the dairy farming of its hinterland; a considerably heavier traffic on the Waitara line (255) reflects the activity of a large freezing works near its terminal.

EASTLAND

The railways of Eastland, including all lines east of Palmerston North and north of Masterton, are composed of one dead-end main line and three branches. Dominant is a general increase in traffic towards Palmerston North, revealing the focal position of its junction, although the Rimutaka tunnel has reduced its role as the rail gateway to Eastland. Nowhere, even on main lines, is traffic more than moderate and much of the main line (in accord with population, production and position) has low density.

The solitary dead-end East Coast Main line links the major urban centres of the most productive and populous agricultural areas with Palmerston North and also gives the region access to Port Ahuriri, the only Eastland port with significant overseas traffic. On the northernmost section, where most of the land if used at all is devoted to extensive pastoralism and where cumulative traffic is at a minimum, densities (412 and 567) are very light. They more than double (1147) southwards from Napier, for this part serves the most productive agricultural areas in Eastland. The Woodville–Palmerston North segment carries considerably more traffic (1727) for it links Eastland and all other parts of the island. North of Masterton the dominant movements were, in 1952–3, to and from Woodville, this part really functioning as a branch of the East Coast Main line. Statistical unity conceals a reduction below the average traffic intensity (880) on this segment, where movements focus on Masterton, though significant contributions are made by the limeworks at Mauriceville.

The Port Ahuriri branch, which links Eastland's busiest wharves with Napier and the main line, carries a relatively heavy (291) traffic composed almost entirely of goods moving to and from the port. By contrast, the Moutohora line, linking the interior hill country to Gisborne and the main line, carries a traffic density which is relatively low (89), but not unusually so for a branch serving extensive pastoralism, for the line is relatively long and remote from other railways.

Inter-System Traffic

The Auckland and Wellington rail systems are joined by two lines: the North Island Main Trunk line and the Stratford Main Trunk line (with a role restricted almost entirely to Taranaki-South Auckland movements).

Coal shipped from near Huntly and from Ohura and timber cut in the upland interior figure prominently in the north-south interchange, which also includes a large volume of manufactured goods railed from Auckland and Wellington, and smaller tonnages of lime and chemical fertiliser which move from South Auckland on to the Wellington system. Agricultural commodities do not constitute an important part of this inter-system traffic, for such goods usually move toward the foci of the rail systems where they are consumed, processed or exported, and those which do move between the systems are confined to small quantities of fruits and vegetables, and limited numbers of replacement livestock.

Another significant feature on the Main Trunk line is passenger traffic. Apart from suburban services, the Main Trunk express trains are the most important feature of the passenger service, and long inter-system journeys are the mainstay of express passenger traffic.

THE RAILWAYS OF THE SOUTH ISLAND

In the South Island the now abandoned Nelson line was separated from the main railnet by more than fifty miles of mountain roads (*Fig.* 2); and, though the main railnet is tied together by a coast-fringing trunk line which carries a vigorous north-south traffic, it has two major functional divisions. North of a traffic col near Glenavy, the railways link the country to Christchurch; southwards, traffic focuses on Dunedin. As in the North Island, the two major functional divisions of the main South Island railnet, like the trade centres on which they focus, compete for traffic originating near their divide.

CANTERBURY AND MARLBOROUGH

The railway north of Glenavy—the Christchurch system—is composed of two major parts which join at Arthurs Pass. East of the mountain ranges lies an extensive network serving Canterbury and Marlborough, integrated by the Lyttelton-Glenavy segment of the Main South line, which carries the heaviest traffic and is the trunk from which all others diverge. Also included are one other trunk line, one much less important dead-end main line, and ten branches.

Main line traffic densities are high near Christchurch, but moderate or low away from the city, while branch line densities range from moderate to extremely low, with low densities predominating. Only on trunk lines bolstered by bridge traffic, and near Christchurch where funnel and cumulative traffic intensifies, do densities rise above the moderate level. On all lines, traffic increases towards the main lines and, on these, it increases towards Christchurch.

The three main lines connect Christchurch with the economic foci of the northern, western and southern parts of the South Island, with the extensive pastoral lands of the High Country, with the much more productive arable mixed-farming areas on the Canterbury Plains. Main South line traffic density, lowest (1459) near Glenavy, increases northward (2013) as the populous, productive tract widens, as cumulative traffic increases and as tributary lines are contacted. The Christchurch-Lyttelton section has a traffic density (3925) which far exceeds that in any other part of the island, for it handles a very heavy freight traffic between the largest city and the most active port and carries frequent electric suburban trains.

The Midland Trunk line connects the extractive activities of Westland with the markets of populous Canterbury. Though much of this railway traverses the alpine terrain and open tussock grassland of the High Country, traffic density is remarkably uniform and relatively high (1680), such characteristics reflecting the dominant role played by the large volume of bridge traffic, composed primarily of coal and timber moving eastward into Canterbury.

The Main North line is a dead-end line, connecting Christchurch with the nodes of productive agricultural land and the few small population clusters of Marlborough, along with the extensive pastoral areas of northeastern Canterbury and the arable mixed-farming districts on the plains south of Waipara. On the northern portions of this railway, traffic densities (380 and 474) are extremely low for a main line—a reflection of the small population, meagre economic activity, and an 'out-on-a-limb' position in the railnet. South of Waipara, where the line 'funnels' the traffic of three branches, density more than doubles to reach a modest level (1025).

Six of the ten Canterbury branch lines link secondary trade centres on the plains with main lines. The simple relationship of traffic densities to commercial significance of the towns and farming districts is best exemplified by the Methven (83) and Springburn (43) branches. The Southbridge line has an abnormally heavy average density (123) because its northern section 'funnels' the traffic of the Little River branch. Competition from other railways helps to produce unusually light traffic on the closely parallel Oxford West (26) and Horrelville (15) branches, while the relatively light traffic (42) on the short Waihao Downs branch reflects the proximity of its stations to the main line.

On the Waiau and White Cliffs branches, traffic based on trade centres serving productive agricultural districts is augmented by extractive activities, the Waiau branch traffic having a higher density (136) than any other because of heavy loadings of lime and timber, while the White Cliffs branch (43) handles some of the output of a small coalfield. The Little River (69) and Fairlie (84) branches diverge from main lines on the plains and terminate in railheads which serve pastoral farming districts, though additional traffic comes to the Fairlie branch from a coal mine and limeworks.

WESTLAND

The small railnet west of Arthurs Pass superficially appears to be an independent unit whose primary foci are coal-shipping ports on the

Westland coast, but in fact it functions as part of the Christchurch rail system, a fact indicated by the heavy cross-island traffic moving over the Midland line.

The railways of Westland consist of one trunk line, one dead-end main line, and six branches. On the main lines, traffic densities range from moderately high to low, but because of heavy loads of coal and timber branch densities are unusually heavy for feeder lines serving such a small population. The pattern of traffic densities is complex. On most parts of the Midland line there is a general increase towards Christchurch but on the western part, on the Stillwater-Westport line, and on the branches, there are local increases towards Westport and Greymouth. This clearly reveals the two distinct functions that these railways perform: they link the extractive activities of Westland with consuming centres elsewhere, and they connect mining areas with the coal-shipping ports of Westport and Greymouth.

Activity on the Midland trunk line east of Stillwater is dominated by bridge traffic between stations to the west and Canterbury, this dominance being reflected in the remarkable uniformity of traffic density. The moderately high level of activity (1646:1673) reveals the intensity of interchange across the Southern Alps. Great tonnages of coal and timber are hauled eastward, whilst much small quantities of foodstuffs and manufactured goods are taken into Westland. West of Stillwater a heavier traffic, increased by movements to and from the Stillwater-Westport line and by coal traffic originating on the route, focuses on Greymouth.

The dead-end Stillwater-Westport line connects Greymouth with Westport, and northern Westland with the Midland line and thus with the rest of the island. It forms a single statistical unit with a traffic density (554) quite low for a main line. However, heavy traffic on the southern part focuses on Greymouth, while lighter movements on the northern sections centre on Westport and there is a traffic col between Inangahua and Reefton. The major contributions come from coal mines and timber mills.

Branch lines carry unusually heavy traffic. Five of these link major coalfields and their dormitory towns with coal-shipping ports and with main lines affording access to other parts of the South Island. Coal movements into Greymouth give the Rewanui branch a greater density (745) than any other in the South Island. The line to the Mokihinui Mine has also a heavy coal traffic. Data are not available for the Rapahoe, Roa Bins and Conns Creek branches, but all carry large volumes of coal. The Ross branch links Hokitika, a secondary trade centre, and Ross, the railhead for southern Westland, with Greymouth and the rest of the railnet, but it is large quantities of timber that give this line its relatively heavy traffic density (361).

THE OTAGO SYSTEM

Within the large Dunedin system are two semi-independent functional parts. North of Pukerau are the lines of Otago; to the south of this slight traffic col are those of Southland (*Fig.* 2).

The railways in Otago are immediately tributary to Dunedin, and consist of one coast-fringing trunk line and ten diverging branches. Traffic density is moderate on the trunk line which is bolstered by bridge traffic, and ranges from extremely light to moderately heavy on the branches, which usually reflect limited population and production. Throughout Otago, traffic densities increase toward the Main South line and Dunedin; the importance of connections with Canterbury and Southland is also indicated by the intensity of traffic through the cols that limit this system.

The Main South line ties the populous and productive coastal fringe of Otago to Dunedin, provides access to Canterbury and Southland, and 'funnels' the traffic of ten Otago branches to and from Dunedin. Traffic density increases southward from the col at Glenavy (1,459) for, though the immediate hinterland becomes agriculturally less productive, funnel and cumulative traffic increase towards the regional centre (1545;1895). Lime quarries around Waiareka and coal mines near Palmerston contribute, and immediately north of Dunedin additional passenger and freight traffic moves to and from suburbs, industrial establishments and the docks at Port Chalmers.

The Dunedin-Balclutha section of the Main South line has the heaviest traffic density (2,140) in Otago. Here it passes through the most closely-settled and agriculturally productive part of the region, taps Otago's primary concentration of mining activities (where both limeworks and coal mines offer large tonnages of freight) and funnels the Dunedin traffic of four tributary branches.

West of Balclutha, traffic density falls sharply to a moderate level (1,472). The major feature here is bridge traffic between Southland and depots north of Balclutha. The small market towns in the farming districts adjacent to the railway, and traffic to and from the Edievale branch, make smaller contributions.

Four of the ten Otago branches connect the Main South line with market towns in the intensively-farmed coastal area and serve as railheads for the interior intensive pastoral zone. The direct relationship between traffic densities and the commercial significance of 'on-line' towns is best exemplified by the Kurow (70) and Ngapara (61) branches, and on the Edievale line (101), where timber is significant. The Outram branch, short, and close to the main line and to Dunedin, had one of the lightest traffic densities (18) found anywhere in the country.

Two Otago branches terminate in railheads which serve large extensive pastoral farming districts and also link centres of extractive activity to the Main South line. The relatively heavy traffic (105) on the short Dunback line is due largely to cement and lime works, while the lighter traffic (85) of the Talakopa branch includes much timber from the southern part of its route.

The other two Otago branches are long lines reaching scattered productive nodes in the rugged interior. Traffic on the Otago Central line is higher (300) than on any other Otago branch chiefly because its length of 147 miles assures it both cumulative traffic and a large hinterland remote from other railways. Shorter but similar in function, the Roxburgh branch carries the second highest traffic density (154) on Otago branch lines.

SOUTHLAND

The railways of Southland consist of one trunk line, three secondary main lines and seven branches. Traffic densities vary from moderate to low on the trunk line which, because of peripheral location, carries little bridge traffic, though it strongly links Southland with Invercargill and the rest of the island. Branch and secondary main line densities range from extremely light to heavy.

The Main South line links Southland's major trade centres with Dunedin and other points outside the region, ties the most populous and productive parts of Southland to Invercargill and 'funnels' the traffic of several branches to and from this town. Although the Invercargill-Balclutha section is a single statistical unit, there is a continuous increase from the low density col near Pukerau towards both extremities. Traffic is considerably heavier (1,472) on this section than elsewhere in Southland, for it carries goods and people between other parts of New Zealand and Invercargill, funnels the Invercargill traffic of three branch lines, traverses the districts where most people live and farming is most intensive and serves a concentration of market towns and heavy industries.

Traffic on the Invercargill-Bluff segment consists very largely of goods moving in and out of Southland's solitary port and one of its major freezing works, and is considerably lighter (919) than that north of Invercargill. This pattern suggests that the link with Otago rather than with Bluff is the principal external connection, and demonstrates the fundamental unity of the Dunedin system.

Southland's Secondary Lines

Three secondary lines, which function as main lines, play an important role. The longest of these is that which ends at Kingston. This single statistical unit has a traffic density (244) which is light by main line standards, but heavy for a South Island branch—a generalisation which conceals continuous increases towards Invercargill. Density is quite heavy on the southernmost part where western branch traffic and a major freezing works contribute, but declines to a moderate level between Makarewa and Lumsden where it funnels traffic to and from three branches, and serves two minor trade centres and a principal lime-quarrying district. North of Lumsden it penetrates the extensive sheep-rearing areas of the High Country and carries an extremely light traffic.

The Orawia line funnels traffic to and from the Wairio branch and thus acts as a dead-end main line. Traffic density differs sharply from part to part, although most is a single statistical unit with a relatively high branch density (314). On the easternmost part, where coal moves from the Wairio branch, traffic is much the heaviest. On the western part, activity is dominated by timber haulage; general traffic moving in and out of the minor 'on-line' trade centres is subordinate. North of Tuatapere, an extremely low traffic density (26) points to the undeveloped nature of the hinterland and lack of cumulative traffic.

The Gore-Lumsden line, which also functions as a main line, is one of the few secondary railways with connections at both terminals. It has a low traffic density (68) which is uniform throughout, for major trade centres of the grain and sheep-producing districts are situated near its mid-point, as also are a minor concentration of limeworks and the junction of the diverging Switzers branch. A small quantity of bridge traffic also contributes to this uniformity.

Three Southland branches link minor trade centres in intensive farmlands with main lines. Variations in traffic densities among the Waikaka (60), Wyndham (46), and Hedgehope (37) branches correlate closely with the varying commercial significance of 'on-line' towns. Three other branches diverge from main lines on the productive plains and tie centres of extractive activity into the railnet. Outstanding is the Wairio branch which carries a very heavy coal traffic (667) from the Ohai field. The Tokanui branch, traversing the Southland Plain, terminates in a railhead for sheep stations and timber-cutting operations in the hills to the east, while heavy lime and fertilizer receipts are important causes of its relatively high traffic density (101). The Mossburn branch, laid across a plain with mixed crop - livestock farming, serves great areas of extensive grazing land and wilderness in western Southland, and has its traffic density (59) considerably augmented by serpentine loadings from the quarry near Mossburn. On the Switzers branch however traffic is extremely light (28), for its hinterland contains only scattered sheep stations.

Inter - System Traffic

Traffic between the Christchurch and Dunedin systems flows over the Main South line, the backbone of both systems. Among the commodities which move in large volume between the two systems are manufactured goods made or received from overseas in the Christchurch urban area or, less commonly, at Dunedin, timber and coal from Westland, southern Otago and Southland and a large lime tonnage which originates in North Otago and moves into Canterbury.

As in the North Island, agricultural goods do not form a major part of inter-system traffic; they usually move locally for processing, or for export, or for domestic consumption. However, the movement of replacement livestock is more common here than in the North Island, and a north-south interchange of fruits and vegetables occurs. Another similarity between the South and North Island railways arises from the fact that (excluding suburban services near Christchurch and Dunedin) the most important passenger movements are long distance inter-system journeys.

The Nelson Railway

The Nelson line was in 1952–3 the third unit and the only 'isolated' line in New Zealand (*Fig.* 2). Traffic density was very low (30), reflecting not only the small population and limited economic activity but more directly the complete lack of long distance and bridge traffic because of the separate position of the line.

The line was a single statistical unit, but traffic density increased continuously towards Nelson, demonstrating that its junction was to link the extensive pastoral farms of the interior and the closely-settled, agriculturally-productive Waimea Plain with Nelson city and port. Traffic towards Nelson was composed largely of agricultural goods, and some timber from 'outer' areas. Southward movements consisted largely of locally manufactured or imported goods and agricultural supplies, and a significant supply of timber received from ships or processed in Nelson.

CONCLUSION

It is evident that the traffic on a given section of railway may be based on the presence of population, or of centres of production or consumption; or it may result, on the other hand, from the position of a section of line within the railnet—thus, main lines carry 'bridge' and 'funnel' traffic, and the immediate hinterlands may have little significance. Furthermore, on all lines there is some 'cumulative' traffic near the principal centres. Traffic on 'tentacles' that extend far from the rest of the railnet tends to be heavy relative to local economic activity, because such remote areas require comparatively large amounts of long distance transportation, and stations are remote from the competition of other railways.

A comparison of the railways of the North and South Islands in terms of both total traffic and density reveals great disparity The fact that traffic density in the North Island is more than twice that of the South Island is directly related to the marked differences in population and production.

In the overall pattern, the predominance of the main lines is striking. In each island, the volume handled by the most important trunk line exceeds that of *all* other railways. The large branch mileage of New Zealand plays but a small part in total railway activity; it is the heavy-traffic main lines connecting the major centres, and a few heavy-traffic branches serving areas that produce or consume large quantities of bulky commodities, that are primary. In the North Island, the railway linking Auckland and Wellington is pre-eminent. Relatively heavy traffic also occurs on lines to and from the productive plains of South Auckland, and on those linking Wanganui and Napier with the Main

Trunk. Unusual traffic density occurs on the Johnsonville branch, in the Wellington suburban area and on the Glen Afton branch serving the North Island's major coalfield.

Two South Island railways are outstanding for the volume of their traffic: the Main South line which parallels the east coast and links the largest cities; and the Midland line which ties the extractive activities of Westland to the consuming centres east of the Southern Alps. The South Island branch lines which carry the heaviest traffic tap the coalfields of Westland and Southland.

As would be expected in a country whose economy is on an export-import basis, most large urban commercial centres are also important ports. Consequently, in addition to providing a measure of the influence of major commercial centres on the extent of their hinterlands, the railway traffic pattern also defines the tributary areas of the associated ports. The North Island pattern is characterised by a focusing on the two principal centres and ports, Auckland and Wellington, and a local increase towards New Plymouth, the regional centre of Taranaki and the North Island's third-ranking overseas port, and—although limitations of data prevent accurate measurement—towards Napier, one of the two largest trade centres in Eastland and the fourth-ranking overseas port.

The dominance of Christchurch and Dunedin in commerce and port activity is expressed by the South Island pattern. In Southland, the regional focus on Invercargill and the Bluff is evident, while the only important ports that are not associated with major trade centres nor engaged in overseas commerce are Greymouth and Westport. These receive large tonnages of coal by rail, primarily for shipment to the North Island.

DIURNAL VARIATION OF RAINFALL IN NEW ZEALAND

W. J. MAUNDER

MOST of the activities of man are conducted during the daylight hours. Rain occurring during this period may therefore result in a loss of working time, and in some cases considerable inconvenience. The concentration of rain about certain hours of the day is therefore of considerable importance alike to contractors, labourers, farmers, caterers or meteorologists.

Recent investigations of the diurnal variation of rainfall in New Zealand, have shown that there is considerable variation in the diurnal rainfall regimes from one part of the country to another, although, as would be expected, these diurnal variations are not as pronounced as in some inland continental areas and in some tropical islands.

The autographic rainfall records from sixteen stations with records varying from five to twenty-seven years were used in this investigation of the diurnal variation of rainfall. The initial data used were the New Zealand Meteorological Service tabulations of the rainfall recorded in each hour of the day, these being then grouped into eight three-hourly periods, midnight to 3 a.m., 3 a.m. to 6 a.m., etc. The monthly figures (averaged over the length of record) were grouped to provide seasonal data, summer being taken as December, January and February. A set of tables was constructed showing the average rainfall occurring within each three-hourly period for each month and season of the year. Table I is a condensation of some of these.

An account of the diurnal variation of rainfall at four of the sixteen stations—Ruakura (Hamilton), Kelburn (Wellington), Hokitika, and Christchurch—follows.

REPRESENTATIVE STATIONS: RUAKURA (HAMILTON)

Examination of the data for the period April 1946–December 1954 at Ruakura shows that throughout the year there is a fairly pronounced rainfall maximum during the afternoon and evening, this being most marked in summer, autumn and spring. The periods of minimum rainfall, on the other hand, occur during the late evening and in the morning, the minima being most pronounced in summer and spring. (Table I and *Fig.* 1). During eleven months of the year, more rain occurs during

TABLE I

Average Rainfall* Occurring Within Three-Hourly Periods

PERIOD	00–03**	03–06	06–09	09–12	12–15	15–18	18–21	21–24
RUAKURA, Hamilton. Apr. 1946–Dec. 1954								
Summer	91	87	73	103	100	135	108	70
Autumn	139	138	132	138	137	185	145	147
Winter	166	187	187	142	192	199	194	163
Spring	89	149	142	129	168	176	154	107
Year	485	561	534	512	597	695	601	487
KELBURN, Wellington. Jan. 1928–Dec. 1954								
Summer	155	152	139	114	111	119	110	136
Autumn	161	142	122	135	131	149	140	152
Winter	194	186	182	191	177	184	173	194
Spring	147	174	144	135	124	133	137	142
Year	657	654	587	575	543	585	560	624
HOKITIKA. Feb. 1945–Jan. 1955								
Summer	411	434	435	336	286	281	324	384
Autumn	324	385	364	340	306	301	259	296
Winter	361	363	304	328	332	357	338	344
Spring	423	406	303	280	266	312	348	403
Year	1519	1588	1406	1284	1189	1251	1279	1427
CHRISTCHURCH. Jan. 1929–Dec. 1954								
Summer	99	85	88	64	67	88	87	90
Autumn	83	91	95	76	76	83	103	89
Winter	88	98	101	85	80	82	95	95
Spring	75	74	79	61	64	62	79	76
Year	345	348	363	286	287	315	364	350

* In hundredths of an inch.
** N. Z. Standard Time.

the day (here arbitrarily taken as 9 a.m. to 9 p.m.) than during the night, the months August to February averaging 58.0 percent of their average rainfall during the day. February (62.4 percent) has the highest percentage of rain during the day. July is the only month with a nocturnal rainfall maximum.

An analysis of the ninety-six monthly three-hourly periods during the year shows that there are thirty-two periods with more than 14.0 percent[1] of the average monthly rainfall, twenty of these periods occurring in the afternoon and early evening. The 3 p.m. to 6 p.m. period during all months except May and July, has more than 14.0 percent of the average monthly rainfall. Thirty-four periods have less than 11.0

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[1] The average rainfall (percentage values) expected in any three-hourly period is 12.5 percent, and a departure of 1.5 percent was taken as indicating a significant variation from average conditions.

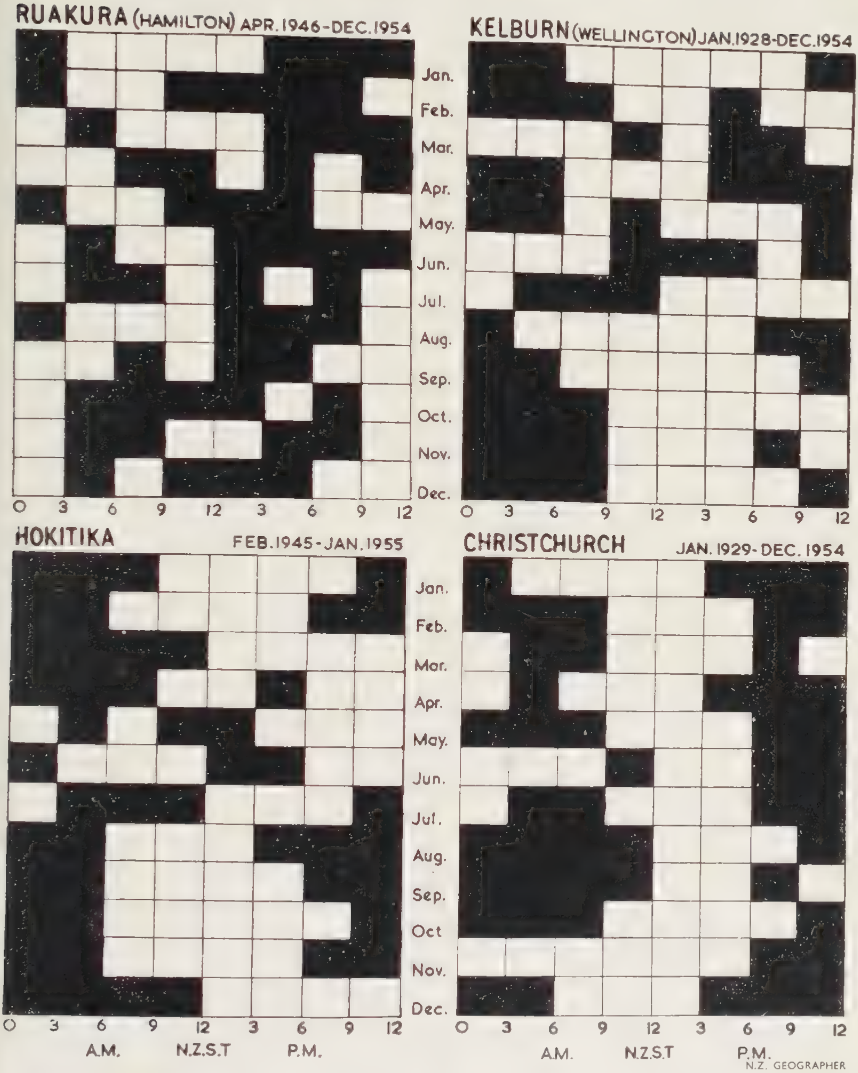

Fig. 1. Monthly three-hourly rainfalls for four stations. Periods with more than the average rainfall expected in a three-hourly period (12.5 percent or more) are shown in black

percent of the average monthly rainfall, fifteen of these periods occurring at night between 9 p.m. and 3 a.m.

The highest average monthly rainfalls occurring in a three-hourly period are 0.81 in. from 3 p.m. to 6 p.m. in November, and 0.80 in. from 3 p.m. to 6 p.m. in June; whereas the corresponding lowest rainfall is 0.17 in. This occurs three times during the year in the periods

3 a.m. to 6 a.m; 6 a.m. to 9 a.m.; and 9 a.m. to noon, all of them being in February.

KELBURN (WELLINGTON)

At Kelburn, data for the twenty-seven year period January 1928–December 1954 show that during spring and summer there is a rainfall maximum during the morning and a minimum during the afternoon, this diurnal variation being most marked in summer. During autumn, the maximum occurs in the early morning, with a secondary maximum in the evening, the minimum rainfall occurring about midday. In winter the variation is almost negligible. During ten months, more rain occurs during the night than during the day (9 a.m. to 9 p.m.) this being in marked contrast to Ruakura where only one month has a nocturnal rainfall maximum. The summer months average 56.3 percent of their rainfall during the night, February having the highest percentage. March (47.4 percent) and June (49.5 percent) are the only two months with a nocturnal minimum of rainfall.

Sixteen three-hourly periods have more than 14.0 percent of the average monthly rainfall, eleven of them occurring in the early morning between midnight and 6 a.m. Sixteen periods also have less than 11.0 percent of the average rainfall, seven of them occurring between 6 a.m. and 3 p.m. during the months January to May.

The lowest average monthly three-hourly rainfalls are 0.27 in. for noon to 3 p.m. in January, and 0.27 in. for 3 a.m. to 6 a.m. in March, whereas the highest rainfalls are 0.72 in. for the period midnight to 3 a.m. in August, and 0.72 in. for 3 a.m. to 6 a.m. in October.

HOKITIKA

The eleven years' record to January 1955 from the South Island west coast station Hokitika reveals that during spring, summer and autumn, there is a relatively marked rainfall maximum in the early and mid-morning, whereas the minimum rainfall occurs during the afternoon and evening in autumn, and during the afternoon in spring and summer. In winter the variation is very small. Ten months have more rain during the night (9 p.m. to 9 a.m.) than during the day, this being similar to the situation at Kelburn. The spring and summer months average 57.0 percent of their average rainfall during the night, March (59.3 percent) having the highest proportion of rainfall at night. Both May (49.4 percent) and June (45.5 percent) have a nocturnal minimum of rainfall.

Of the ninety-six monthly three-hourly periods during the year, twenty-four have more than 14.0 percent. of the average monthly rainfall, all but three occurring during the night. Twenty-five periods have less than 11.0 percent of the average monthly rainfall, seventeen being for the interval 9 a.m. to 6 p.m., and nine for the early afternoon between noon and 3 p.m.

The highest average monthly three-hourly rainfalls are 1.77 in. for the period 6 a.m. to 9 a.m. in December, and 1.60 in. for midnight to 3 a.m. in February. The corresponding lowest rainfalls are 0.44 in. for 6 p.m. to 9 p.m. in March, and 0.65 in. for the interval noon to 3 p.m. in September.

Christchurch

Data for the period January 1929 to December 1954 were considered for Christchurch. Generally there are periods of maximum rainfall in the evening and early morning, whereas the minimum occurs about midday. This midday minimum is quite pronounced in all seasons. In autumn, winter and spring the maximum rainfall occurs from 6 a.m. to 9 a.m. and from 6 p.m. to 9 p.m., whereas in summer the maximum occurs in the early morning between midnight and 3 a.m. As in Kelburn and Hokitika, Christchurch has ten months when more rain occurs during the night than during the day. Four months—February, August, October and December—have more than 55.0 percent of their rainfall at night, October (57.3 percent) having the highest proportion of nocturnal rainfall. June (48.5 percent) and November (49.9 percent) are the two months with a minimum of rainfall at night.

Twenty of the ninety-six monthly three-hourly periods have more than 14.0 percent of the average monthly rainfall. All of them occur between 3 p.m. and 9 a.m. All sixteen periods with less than 11.0 percent occur during the day.

The highest average monthly three-hourly rainfalls are 0.42 in. for the period midnight to 3 a.m. in December, and 0.42 in. for the three hours 6 a.m. to 9 a.m. in May, the corresponding lowest rainfalls being 0.15 in. for 9 a.m. to noon in November, and 0.17 in. for 9 a.m. to noon in December.

Diurnal Rainfall Regimes

The autographic rainfall records at sixteen New Zealand stations—four of which are described above—formed the basis for assessing regional patterns in the diurnal variation of rainfall.[2]

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[2] Because only sixteen stations having suitable autographic rainfall records were available—only eight of which had records exceeding ten years—the coverage is necessarily inadequate for a complete regional survey.

Generally stations in the north of the country have a rainfall maximum during the afternoon, stations in the west and south of the South Island and about Cook Strait have a rainfall maximum during the night, while at eastern stations the time of the maxima is variable. However, because of the nature and distribution of land in New Zealand, the pattern is far from simple when considered in any detail, differences rather than similarities being the salient features.

DAY-NIGHT DISTRIBUTION OF RAIN

In *summer* all stations south of Milson (Palmerston North) have more rain during the night than during the day. (See Table II). An area index shows that at six South Island stations and at Kelburn, 54.5 per cent of the total rainfall occurs at night. Stations with a westerly exposure have a fairly pronounced maximum rainfall at night, whereas stations north of a line from Napier to New Plymouth have more rain during the day, Tauranga being the only exception.

TABLE II

PERCENTAGE OF SUMMER RAINFALL OCCURRING DURING NIGHT (9 P.M.–9 A.M.) AND DAY (9 A.M.–9 P.M.)

Maximum Rainfall During Night		Maximum Rainfall During Day	
Hokitika	57.3	Ruakura	58.4
Kelburn	56.3	Whenuapai	53.0
Invercargill	56.3	Kaitaia	52.9
Nelson	55.8	Mechanics Bay	52.8
Christchurch	54.0	Gisborne	52.1
Tauranga	54.0		
Woodbourne	50.9	New Plymouth	50.5
Taieri	50.7	Napier	50.2
Milson	50.3		

During the *autumn* months (March, April and May) the most noticeable feature of the diurnal variation of rainfall is that Gisborne and Napier have a fairly pronounced maximum rainfall at night, in contrast to their minimum at night during summer. This is revealed by Table III. Woodbourne and Nelson on the other hand have similar but reversed effects. Tauranga, Hokitika and Invercargill, as in summer, have rainfall maxima of some significance during the night, whereas

TABLE III

PERCENTAGE OF AUTUMN RAINFALL OCCURRING DURING NIGHT (9 P.M.–9 A.M.) AND DAY (9 A.M.–9 P.M.)

Maximum Rainfall During Night		Maximum Rainfall During Day	
Gisborne	55.7	Woodbourne	55.2
Napier	55.4	New Plymouth	54.8
Invercargill	54.5	Nelson	54.8
Tauranga	54.0	Ruakura	52.1
Hokitika	53.5	Milson	51.5
Taieri	52.5		
Christchurch	51.2		
Kaitaia	50.7		
Kelburn	50.6		
Whenuapai	50.4		
Mechanics Bay	50.3		

at Kaitaia, Mechanics Bay and Whenuapai, the summer maximum during the day is reversed.

The small variation at many of the stations is the most significant feature of the diurnal variation of *winter* rainfall, Milson being the only station having a significant maximum of rainfall during the night. Mechanics Bay and Tauranga on the other hand are the only two stations with a similar maximum during the day. The winter variation is shown in Table IV.

TABLE IV

PERCENTAGE OF WINTER RAINFALL OCCURRING DURING NIGHT (9 P.M.–9 A.M.) AND DAY (9 A.M.–9 P.M.)

Maximum Rainfall During Night		Maximum Rainfall During Day	
Milson	53.6	Tauranga	56.4
Gisborne	52.8	Mechanics Bay	53.1
Christchurch	52.6		
Woodbourne	52.5		
Nelson	52.3		
New Plymouth	52.0		
Kaitaia	51.8		
Taieri	51.8		
Kelburn	51.0		
Invercargill	50.7	Ruakura	50.9
Hotitika	50.2	Napier	50.8
Whenuapai	50.0	Whenuapai	50.0

In many respects the diurnal variation of rainfall during *spring* (September–November) is similar to the summer variation. Stations in the west and south of the South Island and about Cook Strait have fairly pronounced rainfall maxima during the night, whereas stations in the northeast of the North Island have most rain during the day (Table V).

TABLE V

PERCENTAGE OF SPRING RAINFALL OCCURRING DURING NIGHT (9 P.M.–9 A.M.) AND DAY (9 A.M.–9 P.M.)

Maximum Rainfall During Night		Maximum Rainfall During Day	
Nelson	56.1	Ruakura	56.1
Hokitika	56.0	Taieri	55.7
Invercargill	55.0	Gisborne	54.4
New Plymouth	53.5	Whenuapai	53.9
Kelburn	53.5	Kaitaia	53.0
Christchurch	53.0	Tauranga	52.5
Woodbourne	52.5		
Napier	50.5	Mechanics Bay	50.6
Milson	50.4		

THREE-HOURLY MAXIMA

The maximum three-hourly rainfall occurs during the night (9 p.m. to 9 a.m.) at Kelburn, Hokitika and Invercargill in all seasons, and at New Plymouth for three seasons. On the other hand the maximum three-hourly rainfall occurs during the day (9 a.m. to 9 p.m.) at Whenuapai and Ruakura during all seasons, and at Mechanics Bay, Gisborne and Napier for three seasons. Considered annually, the time of occurrence of the maximum three-hourly rainfall is shown in Table VI.

THREE-HOURLY MINIMA

During all seasons at five stations—Milson, Napier, Christchurch, Taieri and Invercargill—the minimum three-hourly rainfall occurs during the day. Four other stations—Whenuapai, Kelburn, Nelson and Hokitika—have their minimum during the day for three seasons. In contrast, Mechanics Bay, Ruakura, Gisborne and Woodbourne have their minimum three-hourly rainfall during the night for three seasons. Table VII shows the period of occurrence of the minima for all stations on an annual basis.

TABLE VI

OCCURRENCE OF THREE-HOURLY MAXIMA OF DIURNAL RAINFALL (ANNUAL)

Time	Stations
Midnight – 3 a.m.	Milson Kelburn Christchurch
3 a.m. – 6 a.m.	New Plymouth Hokitika Invercargill
Noon – 3 p.m.	Kaitaia Whenuapai Mechanics Bay Woodbourne
3 p.m. – 6 p.m.	Ruakura Tauranga Napier
6 p.m. – 9 p.m.	Gisborne Nelson Taieri

TABLE VII

OCCURRENCE OF THREE-HOURLY MINIMA OF DIURNAL RAINFALL (ANNUAL)

Time	Stations
Midnight – 3 a.m.	Mechanics Bay
9 a.m. – Noon	Tauranga Gisborne Napier Milson Nelson Christchurch Taieri
Noon – 3 p.m.	Kelburn Hokitika Invercargill
6 p.m. – 9 p.m.	Kaitaia Whenuapai Woodbourne
9 p.m. – Midnight	Ruakura New Plymouth

CONCLUSION

Over most of New Zealand the diurnal variation of rainfall is small. However, at Ruakura (Hamilton), Kelburn (Wellington), Nelson, Hokitika, Christchurch and Invercargill, diurnal rainfall variations of some significance occur, especially during the spring and summer months.

No attempt has been made in this study to analyse the diurnal variation in the various types of rainfall, but from overseas investigations[3] it seems probable that the afternoon rainfall maximum in northern parts of the North Island is due in part to the diurnal variation in convectional rainfall, whereas the nocturnal maximum about Cook Strait and in the south and west of the South Island is possibly due in part to the diurnal variation in orographical rainfall.

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[3] See among others: W. Bleeker, and M. J. Andre: 'On the Diurnal Variation of Precipitation Particularly Over Central U. S. A.' *Q. J. Roy. Met. Soc.*, 1951, Vol. 77, pp. 260–271; E. W. Hewson, and R. W. Longley, *Meteorology: Theoretical and Applied*, New York, 1944, pp. 315–319.

GEOGRAPHIC NOTEBOOK

IN THIS ISSUE. The problems of urban sprawl and the decay of older housing areas in New Zealand cities are topics of much current interest and discussion. Dr Pownall's article, based on the case histories of a number of New Zealand towns, therefore comes at an appropriate time and sheds valuable light on the manner in which our towns and cities have grown in the past. Dr Pownall is Senior Lecturer in Geography at Canterbury University College and while on leave of absence in 1957 has studied urban problems and the teaching of urban geography in the United States and north-west Europe. His present paper was originally read to Section P (Geography) at the Dunedin meeting of the Australian and New Zealand Association for the Advancement of Science in January 1957.

Dr. Peter Maling, a medical practitioner of Christchurch, has long had an interest in historical maps and charts. While in Europe recently, Dr. Maling studied little-known maps of early New Zealand in archives in London and Paris. Photostat copies of some of these maps formed the basis of the historical section in the public map exhibition held by the Canterbury Branch of the Society last June.

Dr. C. A. Cotton, Emeritus Professor of Geology at Victoria University College, needs no introduction to readers of the *New Zealand Geographer*. In this article he presents a further aspect of his recent researches in the geomorphology of the Wellington area.

Dr. William H. Wallace is Assistant Professor of Geography at the University of New Hampshire, Durham, U.S.A. For three years Dr. Wallace was a lecturer at Auckland University College and during this time made an intensive study of the geography of New Zealand railways for a Ph.D. thesis at the University of Wisconsin. A previous contribution by Dr. Wallace on the landforms of New Zealand appeared in the April 1955 issue of this journal.

Mr. W. J. Maunder was the first graduate to take a masters degree in geography at Victoria University College. His article on the variation of rainfall throughout the day is an abstract of his M.Sc. thesis. For several years Mr. Maunder has been a forecaster at the Meteorological Office, Wellington. Recently he left for Canada to gain further experience in meteorological work and has been unable to see the proof of this article.

Shorter contributions to this issue have been made by Miss Nancy Northcroft of the Christchurch Regional Planning Authority; Mrs. M. B. Jackson of Dunedin; Mr. B. H. Farrell and Mr. L. Curry of Auckland University College; Mr. W. J. Gardner, Mr. W. B. Johnston and Mr. G. J. R. Linge of Canterbury University College; Mr. A. J. Rose of Canberra University College, Australia; Mr. R. H. Wheeler of Victoria University College; Mr. L. S. Suggate of Christchurch; Mr. A. J. Ross of Papanui High School; Mr. J. L. Hewland of the Christchurch Teachers' College and Mr. I. V. Sage, recently of Taumarunui High School and now a graduate student at the University of Wisconsin.

NEW ZEALAND'S FIRST EXHIBITION OF MAPS. A four-day map exhibition, open to the public from 9 a.m. to 10 p.m. each day, must be regarded as an ambitious project on the part of a branch of the Society. The Canterbury Branch is to be warmly congratulated on having carried through successfully its exhibition on these lines last June, especially as this appears to have been the first of its kind in New Zealand. As a feat of organisation alone it was a remarkable achievement under the vigorous direction of the Branch Chairman, Mr. J. L. Hewland, who organised more than a hundred helpers to set it up and take it down. The exhibition took place in the two large rooms of the Durham Street Art Gallery.

The objects of the display were not merely to demonstrate the technical side of mapmaking and to exhibit examples of the mapmaker's art, but also to illustrate the uses of maps in providing synoptic and accurate charts of topographical features, historical developments and social phenomena. The organising committee flung its net wide, calling upon the resources of the Geography Department of Canterbury University College (contributions were also made by Victoria and Otago Departments), the Geological Survey, the Lands and Survey Department, the Soil Bureau, the Christchurch Regional Planning Authority and the Canterbury Progress League. Dr. P. B. Maling contributed a valuable collection of photostat copies of early charts of the New Zealand area including some specifically concerned with Banks Peninsula and Canterbury; the New Zealand Stamp Collectors' Club had a stand exhibiting a large and fascinating collection of 'map stamps', Whitcombe and Tombs Limited provided an exhibit showing the printing of maps and atlases.

The north gallery was described as the 'Canterbury Room'. Dominating the room was the recently completed land-use map of the area, some 140 square miles, covered by the Christchurch Regional Planning Authority. This, on the scale of 16 inches to the mile, in 88 sheets, covered the greater part of the end wall, and besides attracting an immense amount of interest and attention provided the Branch President, Miss N. Northcroft (the Regional Planning Officer) with a valuable 'text' for her presidential address, given on the night of the official opening by the Deputy Mayor of Christchurch. Of great interest, too, in this room were Dr. Maling's historical maps and charts, photographed from sources in London, Paris and Sydney, many of which had not been shown before, together with some original charts and sketches. Prominent also was the exhibit of the Canterbury Progress League concerned especially with irrigation projects, road development and the proposed tunnel road from Lyttleton to Christchurch. Both Dr. Maling and a panel of speakers from the Canterbury Progress League developed their themes in evening lectures.

A considerable bay in the south gallery was occupied by the Lands and Survey Department; this dealt with such matters as map projection, triangulation, aerial photography, photogrammetry and general cartography, illustrated with much valuable equipment. The Geological Survey occupied another large bay, and exhibited some historic original geological maps of New Zealand as well as modern ones; a notable special exhibit was a large and technically remarkable Russian map of the U.S.S.R. A smaller but significant exhibit by the Soil Survey adjoined this bay. Much of the rest of the gallery was taken up by the University contribution: this aimed, among other things, at showing the development of the representation of relief from the early 'pictorial' stage, at illustrating the characteristic cartography of different periods, at exhibiting examples of modern small and medium scale topographical maps from a large number of countries (particularly Britain and the Netherlands) and illustrating the use of maps for varied geographical purposes such as land use, population and archaeological distributions. The stamp and map-printing exhibits were also in the south gallery.

Having regard to New Zealand's resources in this field there is no doubt that this exhibition was at once bold, imaginative, stimulating and comprehensive. Its educational value was immense not only to the students who participated (many acted as guides and commentators) but to the more than 4000 high school pupils and the 1400 members of the general public who attended. There is evidence that the exhibition was being widely talked about and creating much popular interest when it closed down.—L. S. SUGGATE

GEOGRAPHY AT A.N.Z.A.A.S., 1957. The meeting held in Dunedin in January 1957 was the first conference of the Australian and New Zealand Association for the Advancement of Science to have been held in this country for twenty years. The nineteen papers presented in the geography section ranged widely in area and topic specialisation.

Dr. A. Grenfell Price gave his presidential address on 'Moving Frontiers and Changing Landscapes in the Pacific and its Continents'. Papers in agricultural geography ranged from problems of Samoan village agriculture to land-use changes in New South Wales and a comparison of dairy farming in Wisconsin and the Waikato. There were five papers on the geography of population and settlements, three from Australia and two from New Zealand. Economic geography was represented by studies on the energy regions of New Zealand, the Japanese salmon fisheries, manufacturing in New Zealand and post-war changes in manufacturing in Great Britain. There were four papers on cartography, one on field enquiry techniques and one on the historical geography of the Westland goldfields.

To a newcomer to A.N.Z.A.A.S., Section P (Geography and Oceanography) was mildly disappointing. The section was a tangle—officially consisting of geography and oceanography, but in fact including other subjects: meteorology, microbiology and whole symposia of geology. Attendance at geography lectures naturally enough was reduced by the interest of geographers in a wide range of other subjects.

In many sections of the Conference excited debate, at times almost acrimonious in its vigour, reigned after a provocative paper but on the whole in geography the mere clapping after each lecture seemed to indicate a lack of spirit in the geographic audience. Criticism, constructive or otherwise, was mild or absent but praise, sometimes lavish, followed each paper and tended to be proportional to the entertainment rating rather than to the value of the material presented. Many speakers, hoping to test their research material in public debate, found little critical appraisal or judgement for the exchange of knowledge was almost one way. The spirit of the forum was absent. Because the geographer in research, of necessity, tends to specialize in a narrow field, most speakers were the sole exponents of their particular research topic with the result that helpful criticism flagged for want of either protagonists or antagonists. There being little time left after each paper also curbed discussion of topics. This is a fundamental weakness in such a conference; papers may be read and digested at leisure in periodicals but discussion between an author and his public can come only at such gatherings as A.N.Z.A.A.S. and the N.Z. Geography Conference. Again, discussion might have been enlivened if attendance had been bigger, as audiences were but twenty to forty.

Unlike those attending geology, agriculture or economics sections the geographers rarely gathered for a 'shop-session' or even informal group discussions. This writer, for one, would have enjoyed an afternoon or evening discussing this and that with fellow geographers in New Zealand and those from, and back from, Australia.

Many papers were most demanding of the listener and, as such, were worthy of the conference. A sad minority, however, was more elementary than adult. On the other hand some papers were surprisingly ill-construed, lacking in continuity and containing but snippets of 'digest' knowledge. The illustrations on display and on slides varied from mediocre to brilliant and beautiful pictures and excellent maps.

A warning for future conferences—many papers given in all sections were only faintly related to their titles. Presumably this is caused by the offering of titles many months before the conference so that in the interim many lecturers have had much time to modify their papers and even viewpoints. Another casualty of early planning is the listed speaker who in the event does not attend. To those especially interested in the scheduled papers such changes or omissions are frustrating.

Another disappointment is the non-publication of the papers given at A.N.Z.A.A.S. either for those attending or those people throughout Australasia who, though not present, were greatly interested in the topics offered. Copies of papers to be presented were issued to those enrolled early, but as the conference had an unexpectedly enthusiastic and large attendance, the late enrolments have nothing but memory or manual notes as a record of the conference material.

Through lack of early support, the planned field trip fell through. In its place a number of geographers set out in four cars for a tour of Southland. This informal trip was a marked success.

More than duty prompts acknowledgement of the work of Mr. R. G. Lister and his colleagues in the preparatory work and handling of heavy correspondence in the months before the Conference. Mr. Lister never faltered, and was equal to organising, above the routine conference duties, a very successful field trip, slide viewings, and a most hospitable gathering at his home.

The whole organisation of the A.N.Z.A.A.S. Conference, 1957, was so well run that it was taken for granted by the multitudes attending. The magnitude of the success of the whole complex organisation was matched by its efficiency. The Conference was of great credit to the Otago University staffs and the citizens, private and official, of the city of Dunedin.

For the first Professor of Geography in New Zealand the 1957 A.N.Z.A.A.S. was a triumph of work rewarded. Professor Jobberns was greeted by a host of his former students, many of whom were returned from posts overseas and mustered between them a sizable number of academic successes and research works of note.

—R. H. Wheeler

ATMOSPHERIC POLLUTION. The relatively small industrial centre of a dominantly pastoral economy, powered by hydro-electricity and occupying a narrow low isthmus, swept by the stormy westerlies, is at first sight a peculiar place to provide news of persistent atmospheric pollution. Yet it is occurring in Auckland and has occasioned two small publications by expert investigators. The first, a report to the Auckland Metropolitan Drainage Board by its chief chemist, Mr. R. Hicks, is a description of the results of pollution in the Penrose, Mount Wellington, Te Papapa, Onehunga, Mangere and Otahuhu areas. References are made to paintwork staining black and yellow, 'an acid choking sensation' and 'a rotten egg smell which causes retching and occasionally even vomiting.' The conclusion of the report is that it is discharge from factory chimneys and not from the mudflats of the Manukau which is the main agent in the attacks.

Mr. W. A. Damon, the late Chief Alkali Inspector in Britain, was commissioned by the Minister of Health to make an overall survey of air pollution in New Zealand. His report (*Air Pollution in New Zealand: A report by W. A. Damon*, Government Printer, Wellington, 1957) discusses the technology of the wide range of industries here which may be nuisances without adequate prevention measures: works making sulphuric acid, fertiliser, cement, lime, coal gas, and lead as well as coke ovens and freezing works. Accepted British standards of maximum permitted pollution are listed together with techniques which should be used to achieve them. It is clear, understandably, that New Zealand industries have fallen behind in this respect but governmental, local authority and industrial action following the recommendation of this report, promises to be rapid.

Pollution in Auckland is a local problem. The city does not disgorge sufficient waste into the atmosphere to present the problems of a London; its air circulation is not such that it would ever have the problems of a Los Angeles; its topography is not such as to experience the hazards of a Pittsburgh or a Glasgow. At present only areas adjacent to Westfield are affected, the extent depending on the weather.

In the westerlies of the southwest Pacific are imbedded a train of anticyclones separated by low pressure disturbances so that the pattern of weather in New Zealand is a series of clear days alternating with stormy periods. Anticyclonic weather with its stable air and clear skies, shallow pressure gradients and light winds allows maximum nocturnal cooling and the formation and intensification of inversions, especially where air is relatively stagnant. The 'fumes nuisance' is an affair of the clear night, lifting as the inversion lifts.

The siting of noxious industries is difficult. Along with the usual local siting factors of access to services, economy in construction and in local charges, these industries also require adequate ventilation, and often also require cheap liquid waste disposal. The former are charges borne by the businessman and thus receive close care, while liquid wastes are usually so obvious that they clamour for attention. Atmospheric pollution, moreover, is not very important where population densities are low. However, with the rapid expansion of Auckland in recent years, fume producers, who previously annoyed only a few farmers, now find themselves affecting large city suburbs. Damon's report rightly stresses the remedial action which can be taken by such industries, but one feels nevertheless a certain sympathy for them.

Furthermore, in such a poorly exposed, largely land-locked area as Westfield, it is obvious that considerable nuisance will always exist. There appears to be a strong case for preventing any further noxious industries from being sited in this area. Those existing must of course remain, but meteorological research could perhaps suggest a better smoke-discharge height than that currently obtaining. For further noxious industries, a climatic viewpoint is needed for optimum siting; an area on the east coast, lying high and unobstructed would appear preferable.

An excellent example of the type of climatic research needed is a recent addition to the *University of California Publications in Geography* series by C. P. Patton:'Climatology of Summer Fogs in the San Francisco Bay Area'. The explanation advanced of the dominant conditions favouring the formation of stratus, either aloft or on the ground, is the source region from which the different air masses originate.

Surface cooling by upwelling cold water and by nocturnal radiation from the ground gain importance only when the air arriving is relatively cold initially. The inversion layer observed in all California air masses is described as the result of dynamic heating from subsidence which is either anticyclonic in Pacific air or orographic in Great Basin air.

Patton discounts the role of stratus in reducing temperatures near the ground since the cloud deck is itself associated with an advection of cold air. Conversely, high temperatures are as much, or more, a cause of clear skies than the reverse.

The barrier effect of the Coast Ranges of Southern California and the gap provided by San Francisco Bay provides an interesting case for studying distance of penetration of maritime air into the Central Valley and its effects. Strong pressure and temperature gradients exist in the Bay area and Patton found a nice double logarithmic regression between maximum daily temperatures and distance from the Golden Gate. It seems unfortunate that he did not attempt a similar correlation with absolute instead of relative humidity.—L. CURRY.

NEW ZEALAND MIGRATION TO AUSTRALIA. The interchange of population between New Zealand and the several Australian Colonies prior to the formation of the Commonwealth in 1901 was frequent and mutually beneficial. Andrew Clark has shown in *The Invasion of New Zealand by People, Plants and Animals*, some of the results of this interchange as they are expressed in the New Zealand, and especially in the South Island, landscape. But the process has not been a one way exchange.

In 1947 New Zealand ranked third as an overseas contributor to the Australian population. There were 21,900 persons born in New Zealand as compared with 292,800 from the British Isles and 22,500 from Italy. The New Zealanders were followed by the Greeks (9,100), and the Germans, with 8,955. Since 1947 New Zealanders have lost relative status in proportion to the total Australian population because of the tremendous immigration programme which swelled the numbers of non-Australian born by 620,000 between 1947 and 1954. Thus, although the number of New Zealanders in Australia had increased from 21,900 to 31,000, an increase of 40 percent, they were now outnumbered not only by immigrants from Italy and the British Isles, but also by those from Germany (65,000), Poland (56,000) and the Netherlands (52,000). In addition, their numbers were approached by Greeks (25,700), Yugoslavs (22,700) and Maltese (19,900).

In their pattern of geographical distribution, the New Zealanders differ from other immigrant groups. New Zealanders tend to settle most frequently in New South Wales, this state containing 55 percent of their number in 1954. The only other groups to prefer New South Wales to a comparable degree were the Maltese (47 percent), and the Hungarians (46 percent). A further 26 percent (8,550) of the New Zealanders lived in Victoria, the remainder being scattered through the other States with a tendency for a slightly higher concentration in Queensland.

New Zealanders exceed the normal immigrant pattern in their tendency to congregate in the capital cities. The state capitals together contain 54 percent of the Australian population. Here live 62 percent of the European-born excluding those from the British Isles, and 71.5 percent of the New Zealanders. In both New South Wales and Victoria the proportion of New Zealanders living in the capitals exceeds 76 percent. Melbourne, and especially Sydney, must be included among the cities to which the New Zealand population so persistently drifts. It appears that the New Zealanders who migrate to Australia are fairly high up the socio-educational scale and tend to take up professional occupations, particularly those in commerce, which are most extensively developed in the capital cities. Of all the immigrant groups living in Sydney the New Zealanders are the only ones who cluster in the northern suburbs which are largely given over to residences of middle and upper income groups.

Because of their metropolitan proclivities the New Zealanders are relatively poorly represented in the other major types of Australian social environment. Only 2.8 percent of their number live in the three large non-metropolitan industrial centres of Newcastle, Wollongong and Geelong, compared with 3.8 percent of the Australian total living in these centres. The country towns contain 19.8 percent of the total population, but only 13.3 percent of the New Zealanders, while the comparable proportions for the rural areas are 21.1 percent and 11.3 percent respectively.

While New Zealanders may not expect to regain their relative numerical importance among Australia's immigrants it seems unlikely that there will in future be any diminution of their numbers in the Commonwealth. On the contrary, the tremendous upsurge in the Australian economy during the past decade, together with the more variegated character of Australian society, seem likely to offer steadily increasing inducements to the prospective New Zealand emigrant in the years to come. Although the kernel of truth contained in the assertion that 'New Zealanders are the Scotsmen of Australia' is at present small indeed, the relative prospects of the two countries point to the likelihood that the trans-Tasman route will become steadily more attractive to New Zealand youth.—A. J. Rose

SECOND NEW ZEALAND GEOGRAPHY CONFERENCE. The second Geographical Conference to be organised by the New Zealand Geographical Society will be held in Christchurch from August 25th to 30th, 1958. In view of the success of the first conference held in Auckland in September 1955, a ready response and good attendance by geographers throughout New Zealand can be anticipated. The President of the conference will be Professor G. Jobberns, the Chairman, Mr. J. L. Hewland and the General Secretary, Mr. L. S. Suggate. During the conference it is proposed to hold a dinner for graduates of the Department of Geography, Canterbury University College, to mark the twenty-first anniversary of the establishment of the first University Department of Geography in New Zealand.

A general invitation is extended to members of the Society to offer papers. Each contributor is asked to submit the title of the proposed paper to the General Secretary immediately and a hundred-word abstract by 1 March, 1958. Related papers will be grouped into symposia. Among the symposia it is hoped to have one on 'Problems of the Tropical World' and one on 'Canterbury Today'. Ample time is being reserved on the conference programme for discussion of papers and for a variety of field excursions. All correspondence should be directed to the General Secretary whose address is c/o. Department of Geography, University of Canterbury.

IN OUR CONTEMPORARIES

In Overseas Journals . . .

An Historical Geography of Canterbury

THE SPREAD OF SETTLEMENT IN CANTERBURY, NEW ZEALAND: J. S. Duncan, *Journal of the Manchester Geographical Society*, Vol. 57, 1955, pp. 5-19.

It is exciting to know that a graduate of the Geography Department of Canterbury University College has addressed an English geographical society on his home province and that that society has seen fit to publish his address in its *Journal.* Mr. J. S. Duncan graduated from Canterbury College in 1947, presenting a thesis on the growth of settlement in North Canterbury. This was described in the *New Zealand Geographer* as a pioneer work in using the population map as an analytical tool in this country. In the paper under review, he presents the results of extended researches in this direction. He has mapped population distribution for the whole of Canterbury in 1861, 1886, 1906, and 1951, and then, with these maps as a basis, offers an explanation of the evolution of the present settlement pattern. In general, Mr. Duncan follows the 'past cross-section' approach to historical geography giving a series of geographies of Canterbury at different years. However he also discusses historical events between these dates in order to explain the changes shown in the maps.

The greatest contrast appears between the 1861 and 1886 maps, and reflects the railway-building period. Between the 1886 and 1906 maps, there is some indication of the results of the splitting up of the large estates, especially in the downlands of North and South Canterbury. Between 1906 and 1951 the major contrast is in urban growth, while the pattern of rural settlement seems to have remained static.

In order to give the background of the settlement of Canterbury, both physical and cultural, Mr. Duncan has devoted over half his paper to the 'natural environment' and to the story of its original white settlement. In this section there are some rather vague generalisations (e.g. in his descriptions of the natural vegetation), and some statements that can perhaps be questioned (e.g. he fails to distinguish at times between the ideal 'Wakefield' colony and the colony as planned by the Canterbury Association, especially as regards religious homogeneity and the question of pasturage licences). He seems to pay little attention to the great variation in soils on the plains, to the drainage of coastal swampy areas such as Longbeach, to road transport and the decline of smaller townships, and to irrigation. Such omissions are no doubt the result of lack of space to deal with all aspects of his topic.

Here is a consecutive and well-told story that is obviously the result of thorough research, and the four illustrations are especially well selected. It is to be regretted that this paper is not readily accessible in New Zealand. Mr. Duncan has presented, in the space available, an excellent picture of the growth and distribution of settlement in Canterbury.—J. L. Hewland

Water Power in New Zealand

NEW ZEALAND WATER POWER: PRESENT-DAY PROBLEMS AND DEVELOPMENTS: B. H. Farrell, *Geographical Review*, Vol. 47, No. 2, April, 1957, pp. 194-210.

Mr. Farrell points out that 'like many other countries, New Zealand has experienced a spectacular increase in the consumption of electricity, especially in the last 20 years. Unfortunately, and in contrast with many other countries, the coal deposits are meagre, and about 95 percent of the electricity is generated from water'. The difficulties associated with the development of hydroelectric power are numerous, not the least being the fact that about 30 percent of the population live in the South Island, which has on the other hand some 64 percent of the country's power potential, and yet in which has been harnessed only 8 percent of its 'probably conservatively estimated' resources. Both islands present advantages as well as problems for power development. For example, whilst both have mountainous interiors and sites suitable for dams, yet in the North Island stream flow is at a maximum in winter and is usually much smaller than in the South Island where the potential run-off is held during the winter months in the form of ice and snow.

In just over a decade 'the nation's capacity of water-power plants has increased by almost one and a half times', and yet still the demand has not been satisfied. Unfortunately, whilst the rate of increase in consumption in the North Island is higher than in the South Island the supply potential is much less, and herein lies much of the power problem in New Zealand.

In the light of the title, there is a rather brief but useful section devoted to 'problems and solutions'. Some of the difficulties he mentions are the small population, the utilisation already of some of the best sites, and the control of construction by the state. Furthermore he points out that 'power development has become a political issue time and again' and suggests that 'if the government were to yield to the desires of a forceful but minor section of the community, the result could be conducive to a programme of expediency detrimental to the well-being of New Zealand as a whole'. New Zealanders have been led to expect extraordinarily cheap rates of electricity, and he thinks that a change in this attitude would enable the government to develop the smaller, and usually more expensive, water-power sites. Some of the possible solutions have been aired in public for some time; the underwater cable across Cook Strait, a thermal coal station at Mercer and a geothermal power station at Wairakei are topics of news in the daily press. Under this heading too, Mr. Farrell makes the suggestion that 'an independently controlled organisation' be set up 'empowered to make recommendations, initiate research, and co-ordinate investigations of all New Zealand's energy resources, their associated industries and the utilisation of imported fuels'. This is a sound suggestion but perhaps it is by itself not so much of a solution but rather a means of facing up to the problems.

Mr. Farrell has been undertaking research for several years on the geography of power in New Zealand. Whilst there is a wealth of popular material on various aspects of power production in this country, there are few accounts which attempt to describe the situation in such a concise way. The article is smoothly written and easily digestible, and makes a good introduction for any student of this subject in New Zealand.—G. J. R. Linge

REVIEWS

New Zealand's Economy

NEW ZEALAND: INVENTORY AND PROSPECT. Wellington Branch, N.Z. Geographical Society, Wellington, 1956, pp. 113 (mimeographed).

The Wellington Branch of the New Zealand Geographical Society is to be congratulated for the high quality of *New Zealand: Inventory and Prospect*, published in December 1956, the initiative shown by those responsible for its production and its speedy publication in cyclostyled form.

It contains seven lectures delivered to members of the Branch during that year. The theme is New Zealand's development: and the first paper is appropriately contributed by Professor George Jobberns and entitled 'Life and Landscape: 50 years in Retrospect'. 'Pastoral Farming in New Zealand' is discussed by P. W. Smallfield, and S. H. Franklin, who is already well known for his interest in population and settlement writes on 'Some Demographic Aspects of New Zealand Rural and Urban Communities'. It is most gratifying to have a pedologist join ranks with geographers by producing an admirable soil geography, illustrated by seven maps in the best geographic tradition. I. J. Pohlen has done just this in his paper 'The Role of Soils and Their Environment in the Development of New Zealand', an assessment of 'the way in which soils and their environment have influenced the settlement and development of New Zealand'.

There are two papers on manufacturing. Each tackles the question from a different angle and the reader gains in consequence. W. E. Dalmer's 'Industry: Its Development and Importance in New Zealand' is a long paper almost encyclopaedic in its scope. One can find out for instance that polythene film, casein beads and battery separations are made in New Zealand, that there are seven manufacturers (all named) of fully-fashioned stockings in New Zealand and that the first woollen cloth manufacturing took place in Nelson in 1847-1848. The paper gives a detailed description of the present character of New Zealand manufacturing, accounts of selected commodities, ample basic statistics and valuable reference material.

The second paper by W. B. Sutch, 'Our Changing Industries: Some Reasons Why' gives more attention to the interpretation of present and past circumstances and the analysis of influences affecting the progress and pattern of manufacturing industries. Attention is paid to exploding a popular misconception that the present pattern is the result of exchange control and import selection instituted in December 1938. The growth of manufacturing which has steadily continued throughout the century received its greatest fillip from conditions prevalent during World War II and the resultant momentum began to dissipate in the year 1949-1950 when many items were released from import control. Further items were decontrolled during the next six years and during this period industrial production (contrary to what might be expected) rose at a rate almost equal to that experienced as a result of the war. Dr. Sutch analyses and accounts for these trends, describes the present-day pattern and looks into the future. These are but some items from a most valuable paper.

The final paper is contributed by H. Brian Low and is appositely called 'The Next Twenty Years' his personal view of the years to come. Professor Keith Buchanan, who writes the introduction, reminds us of Dr. Sutch's phrase: 'We have the opportunity of influencing consciously the course of our development' and suggests that 'these papers may help us in some small way to use this opportunity to our fullest advantage'.—BRYAN H. FARRELL.

SCANDINAVIAN PIONEERS OF THE NEW ZEALAND BUSH

FOREST HOMES. By G. C. Petersen. Wellington: A. H. and A. W. Reed, 1956, pp. 137.

This book gives part of the story of Scandinavian emigration and settlement as sponsored by the Vogel government.

The immediate contribution of Dane and Norwegian was to be the penetration of the great Seventy Mile Bush in order to give road access between the Wairarapa and Hawkes Bay. The road workers were allocated farm sections, and most were settled in either the Dannevirke-Norsewood districts or in Mauriceville and Mellemskov (now Eketahuna). It is upon Mauriceville more particularly that this book focuses its attention.

Mr. G. C. Petersen, who is already respected for his historical writings, is himself of Danish descent. Each chapter is suitably prefaced by verse or prose from Scandinavian literature, and these quotations invigorate and deepen the tone of a work already most readable and graphic. The reader shares intimately in the rigours of pioneering isolated bush farms, and yet the text never degenerates into a ramble of anecdotes and unrelated facts.

As the story of an era—one which was shared in its broader aspects by other bush settlements in the North Island of New Zealand—this publication is of great interest and value. The first arduous years were of heavy toil, of danger from crashing logs and from wind-whipped fires, of isolation and loneliness, of hardship and even tragedy. The book recounts the epic of a small group of sturdy pioneers and herein lies its chief merit and main attraction.

No claim is made that this is an exhaustive treatise (unfortunately it is neither documented nor indexed), but the text goes far beyond the local scene of Mauriceville. Scandinavian settlements were especially distinctive in a British colony and Mr. Petersen claims, for instance, that the long association of the two races eased the eventual mingling of their offspring in the antipodes. He maintains that his is not the tale of 'an emigrant people in an alien land' but of the reunion of long-separated kinsmen. At first, deep isolation fostered the continued use of the Danish tongue, and the settlements were noted for the preservation of national customs and the Lutheran faith. But with the development of better access, this cultural fragment merged with that of adjacent areas.

There is but one disappointing feature of this book, and that is the poor standard of mapping. Only one map is attempted and that is constructed crudely. It is meant to show the Scandinavian settlements in the Seventy Mile Bush, but it is incomplete; some of the settlements named in the text are not located, while others on the map escape all other mention. Moreover, no real effort is made to illustrate the fact that this great forest lay along the only practicable lowland route between Wellington and Napier, and yet this was the chief *raison d'être* for these very settlements. Likewise, the inside cover prints of the Mauriceville subdivision have not been fully utilised. It is a joy to read of and to recognize known localities under the guise of pioneer conditions and this map could have been the base for a clearer map of the district. It seems most regrettable that a poorly developed map technique should have detracted, even slightly, from what is otherwise a most commendable book.

—I. V. Sage

An American Looks at Old New Zealand

THE NEW ZEALAND JOURNAL, 1842-1844, OF JOHN B. WILLIAMS OF SALEM MASSACHUSETTS. Edited with an Account of his Life by Robert W. Kenny. Peabody Museum of Salem and Brown University Press, 1956, pp. 120.

How can we get a true picture of that 'Old New Zealand' which flourished before 1840, and declined after the Treaty of Waitangi? Our standard histories on this period are taken up with the discussion of missionary and settlement problems which foreshadow the racial clash to come. Indeed, the material available on these matters is so massive and so absorbing that historians have understandably been reluctant to give their time to seeking out and studying sources on a phase of our history that has had little long-range importance. Yet 'Old New Zealand' has a right to be studied for its own sake. It was largely British-Australian, but there were strong 'foreign' elements. Its history can not therefore be adequately written until American, French, and other overseas sources have been systematically combed for material.

How, for instance, did the motley band of Europeans in New Zealand view the Treaty of Waitangi? There can be little doubt that Hobson's proclamations spelt economic loss or ruin for non-British residents and traders. Indeed, the more effective New Zealand government became, the more unpopular it was with foreigners. 'Old New Zealand', with its opportunities, its delights, and its dangers for all Europeans, gave way to British trade and British colonisation.

Such is the background to *The New Zealand Journal 1842-1844 of John B. Williams*, United States Consul in New Zealand during the middle 'forties. This document (a memoir, sketch for a memoir, not a journal) has been resurrected from a Massachusetts museum and published by Robert W. Kenny, an American who saw army service in this country exactly a century after the subject of his researches was at the Bay of Islands.

One could predict, without opening this handsome volume, that it would contain strong criticism of British rule. Indeed, if it had been the carefully compiled official report that Williams could no doubt have written, it would have been of great historical value. As it stands, it is highly unofficial, highly individual, highly incoherent, and highly entertaining. It adds those splashes of colour (in this case mostly lurid) which are lacking in so much of our historical material, but one can hardly describe it as a document of major importance. This is not the United States Consul writing, but a merchant and Puritan from Salem giving vent to his feelings of commercial frustration and religious horror.

It must be admitted that Williams had ample material on which to comment disapprovingly, though the subject of his criticism is not really New Zealand in general, but the British officials and the European community (mostly British) at the Bay of Islands. 'Of all the places under the Sun I have not a little reason to say it is among the very worst. . . . Not only in Commerce, but in trade, in political and civilian affairs; it has never been my lot to see so perfect a picture of moral depravity, combined with everything disorderly, vicious, illegal, unjust and impolitic.' Attempts have been made by anti-clerical historians to whitewash Kororareka and blacken Paihia, but, even discounting his prejudices, Williams leaves us in no doubt as to the contrast between the settlements on the two sides of the bay. His wrath rises to a magnificent climax on the head of 'J. Guise Mitford . . . Queen Victoria's Sub Collector of Customs', who combined short hours ('10 AM to 2 PM') of slothful business with long hours of brute pleasure. Admittedly Williams saw the Bay in decline after Hobson had moved the capital to Auckland. Kororareka, like Sydney, may have been floated on a sea of rum and gin, but it was not New Zealand.

Passing from the morals of British officials to the wider issues of British policy, Williams writes as a Salem merchant with overtones of sympathy and admiration for the Maoris and the missionaries. Of the Treaty of Waitangi Williams writes, '. . . the New Zealander in his simplicity and innocency were seduced and knavishly dealt by, knocking in the heads of tobacco casks. . . .' Yet Hobson merely observed the commercial formalities to which the Maoris were accustomed.

This does not exhaust the resources of Williams's ungrammatical and splenetic pages. He has much of value on the reaction of the Maoris to British rule and he gives unstinted praise to the work of Methodist and Anglican missionaries among the natives. He breaks off in the midst of discussing matters of historical importance to discourse somewhat tediously on botany, geology, zoology and the wrath to come. The result is that we have a vivid picture of the mind and outlook of John B. Williams, but too little sustained comment on significant developments in New Zealand.

We are grateful to Mr. Kenny and his publishers for giving us so much and whetting our appetites for more. Mr. Kenny's life of Williams which prefaces the *Journal* is actually of more historical value than the latter. Mr. Kenny quotes extensively from Williams's correspondence and despatches, and the value of this material leads one to hope that there are enough sources in the United States for a new full-scale study of American commerce in the South Pacific.

In acknowledging the care and scholarship of Mr. Kenny, one must still observe that the footnotes are inadequate and the maps not clear. Both would have been better entrusted to New Zealanders. The reasons why this *Journal* has been published are fairly obvious. Yet, here in New Zealand, there are dozens of more valuable journals and memoirs urgently needed in printed form. Their publication in cheaper format would surely be possible if the combination of enterprise, cooperation, and generosity which lies behind this book could be conjured up in this country.

—W. J. GARDNER

What's Wrong with Local Government?

LOCAL GOVERNMENT IN NEW ZEALAND. Edited by R. J. Polaschek. Wellington: New Zealand Institute of Public Administration. London: Oxford University Press, 1956, pp. 122.

This book comprises the six papers, together with brief summaries of the discussions, given at the Eighth Annual Convention of the New Zealand Institute of Public Administration in 1956. The editor's useful introduction sets the papers in relation, not only to each other, but to the whole problem of local government. There is also a bibliography and an index. The authors of the papers are W. B. Sutch, T. W. M. Ashby, Sir Bernard Ashwin, K. B. Cumberland, E. Ashcroft and A. A. Mc Lachlan, and both in their experience and in the papers presented, they range widely over the field of local government.

One is left with three strong impressions after reading this book. All the authors draw attention to the same salient points, either explicitly or by inference.

First, that local government is important for 'its essential contribution to the British democratic tradition', because, as the editor says in his introduction, not only does it permit a direct and personal form of administration in which the citizen may make decisions and carry them into effect, but by enabling him to play a part in the day-to-day process of government it provides him with a continuous political education.

Second, that local government is, today, so sick that it is nigh unto death. The causes given are many and various but they might be summed up as—finance, functions and form. In other words, not enough money, not enough interesting work to do, and far too many local authorities. Sir Bernard Ashwin quotes the 1954 *Local Authorities Handbook* as listing 928 local authorities which were then functioning actively. For a country of two million people this is a staggering figure. The symptoms of the disease given are also various, but chief among them is an ever increasing tendency towards centralisation, the central government either taking over more and more of the functions of, or assuming greater controlling interests in, local government.

The third impression is that reform in local government is not only necessary but urgent. Again the remedies suggested are various. One is left, however, with perhaps a fourth impression, vivid and sad, that none of the authors are really hopeful that the necessary reforms will be carried out. In making one aware of this, the book, paradoxically perhaps, will possibly serve its most useful purpose. Local government is important. It is a declining force. It is imperative that it be recreated into a vital structure, but no one is interested.

The papers gathered together in this book, however, are full of interest. All citizens, whether they are directly engaged in local government or not, will find in them a disturbing challenge to a consideration of an important form of government which for years we have taken carelessly for granted, and which now, through apathy or conservatism or both, is slipping away from us. It is to be hoped that the book will be widely read.—Nancy Northcroft

Tales of a Southern City

THE STORY OF EARLY DUNEDIN. By A. H. Reed. Wellington: A. H. and A. W. Reed, 1956, pp. 295.

In presenting the first comprehensive and detailed study of the early history of Dunedin, A. H. Reed has added yet another to his long list of publications concerning the history and legends of various parts of New Zealand.

The Story of Early Dunedin aims to provide 'a detailed account of Dunedin's pioneering days' during the period from the foundation of the settlement in 1848 to the beginning of provincial self-government in 1861. It is to be regretted that this volume covers so brief a period and it might be noted that much of the political material which is included has been described already and in greater detail by McLintock in his *History of Otago.*

However, Mr. Reed confines himself fairly strictly to his subject—early Dunedin—and only a very brief preliminary chapter is devoted to events preceding the actual establishment of the town. Judicious use has been made of a wide variety of reference material though no adequate bibliography or detailed acknowledgement of sources is included. The lack of footnote references and bibliography indicate to some extent the general character of the work which in its easy and pleasant approach may appeal more to the general reader than to the historian or historical geographer.

There are to be found many detailed descriptions of the buildings, streets and various features of the settlement but these tend to be rather rambling and incomplete giving no really comprehensive picture of the whole. In the matter of illustrations, *The Story of Early Dunedin* is of high quality, some twenty-two views of various parts of the town being included, though they are not made particular use of, nor referred to in the text. The justification for the inclusion of so many of James Brown's cartoons and the large number of portraits of prominent men is not so easily determined.

The Story of Early Dunedin is an important contribution to the history of one of the Dominion's major centres and it is to be hoped that a sequel covering the years of even more significant and spectacular development will soon be published.

—M. B. Jackson

Sugar in the South Pacific

SOUTH PACIFIC ENTERPRISE. Edited by A. G. Lowndes. Sydney, Angus and Robertson, 1956, pp. 500.

This is the story of the Colonial Sugar Refining Company Limited as told by nine authors, some of whom are not members of the Company. Its significance lies not only in the Company's control of the sugar industry in Australia, Fiji and New Zealand but also in the fact that there are very few detailed accounts of the history of major industrial concerns in either Australia or New Zealand.

However, this book is not a restricted history, narrowly confined to the origins and development of the Company. Indeed the first chapter outlines the origin, nature and spread of the sugar cane plant throughout the world. To New Zealand geographers the short chapter 'Sugar in New Zealand' will be disappointing, but they will find much of interest in those chapters covering the sugar industries of Fiji and Australia. The evolution of the tenant farming system in Fiji and of the independent cane farms in Queensland are major achievements in human and economic relations.

These and other chapters are well illustrated with informative, clear and colourful maps showing, for example, cane-growing areas serving the various mills in western Viti Levu, or locations and output of raw sugar mills in Fiji. Throughout this book there are many beautiful illustrations both in colour and half-tone. Some of these features undoubtedly reflect the geographical training of the editor, A. G. Lowndes, who has also written the Fijian chapter.

Pervading the organisation for over 75 years are the characters and policies of the Knoxes, father and son, and with them lie the principal reasons for the fostering of the Company and its rise to international rank. It is natural, therefore, that many pages are devoted to the men, the shareholders and the rewards of private enterprise. A series of valuable notes, statistics and a useful index complete a very readable account of an industry with a stake in three South Pacific countries. It is to be hoped that other important companies in New Zealand, Australia and the Pacific Islands will be encouraged by this example to provide equally detailed accounts of their development or to allow students access to their records before these are lost or destroyed.

—W. B. Johnston

Food Crops in the South Pacific

THE PACIFIC ISLANDER'S FOOD CROPS: FOOD PLANTS OF THE SOUTH SEA ISLANDS. By Emile Massal and Jacques Barrau. Noumea: *South Pacific Commission Technical Paper*, No. 94, 1956, pp. 51.

As the authors stress, this paper is a tentative survey of the main food plants used by the South Sea islanders. More detailed surveys are at present being carried out. The paper should, however, prove very useful to all those who are interested in the geography of the South Pacific and especially in the growing and improvement of the food crops.

The paper is divided into three main sections: 'The South Sea Islanders and the Food Plant'; 'The Staple Food Plants'; and 'The Supplementary Food Plants'. Three appendices consist of a list of the common names used in each island group, a list of selected references and a botanical index. There are nearly ninety very clear photographs as well as a number of useful line drawings. These should have special appeal to a geography teacher.

In the introductory chapter the authors suggest that it seems necessary today to enrich the vegetable food pattern of the South Sea islands, to find among the traditional food plants species and varieties which can be retained as part of the new agricultural patterns, and to educate the people in the relative values of local and imported foodstuffs. European influences have frequently affected nutrition adversely and it is necessary to help the islanders to adapt themselves to their new way of life without abandoning all their traditional agricultural techniques and customary foods.

The staple food plants are listed as sago, taro, arrowroot, yams, bananas, cassava and sweet potatoes. The information on each plant includes the botanical and common names, an interesting description with, where necessary, an illustrated key to simplify the identification of related species or varieties, notes on the cultivation, uses, methods of working or processing of the plants in different islands and analyses to show the nutritive values of the food.

The section on the supplementary food plants lists a very wide range of species, both introduced and indigenous, which occur on some, or all, of the numerous islands in the South Pacific. Only brief notes are provided on the majority of these plants.

Food Plants of the South Sea Islands can be recommended to teachers and students as well as to workers in the islands of the South Pacific . —J. W. Parham

A Handbook for Teachers

THE TEACHING OF GEOGRAPHY: by G. H. Gopsill. London: Macmillan and Co. Ltd., 1956, pp. 316.

In this book the author analyses the scope and content of geography as it concerns teachers, and examines many of the problems that face them.

Mr. Gopsill states three major aims that the teacher should keep in mind. These are firstly, that he should strive to give a picture of the way in which people live and the nature of the country on which their living is based; secondly, that he should not be content that his pupils acquire purely factual knowledge but that they should develop a spirit of enquiry and curiosity into the nature of the world about them, and thirdly, that pupils should be given sound habits of study based on 'the fundamental principle that geography deals with realities rather than academic abstractions' (p. 18). Children should be trained to observe or seek information, to record accurately what has been found and then to reason about these observations and attempt to draw conclusions.

As teachers we know that the tempo of our pupils' interest and alertness soon flags if they are engaged on a given task for too long. In the section entitled 'General Principles of Class-Room Practice', Mr. Gopsill stresses the need for variety of occupation among pupils during a lesson. Teachers will find examples of how up to eight different methods of presentation, with their resulting changes of occupation on the part of the pupil, can be incorporated in a forty-five minute geography lesson.

A successful lesson, Mr. Gopsill points out, should contain three basic principles. These are, firstly, that the children should know at the outset the aim and purpose of the lesson, secondly, that their interest should be aroused immediately by some compelling quality e.g. a telling phrase, a dramatic incident or visual aid, and thirdly, that there should be sufficient variety of occupation to maintain maximum interest and activity.

The relative merits of individual assignments and group projects are also closely examined. Here, Mr. Gopsill subscribes to the view that group projects can result in a few doing most of the work and considers that assignments, when detailed instructions are given, are of much more value.

Hints on the uses of visual aids range from the use of the film strip to the ways in which simple models can be constructed to show the meaning of contour lines.

Sketch maps and the strengths and weaknesses of different methods of recording data on maps are also considered.

There are comprehensive bibliographies at the end of each chapter and an appendix contains a useful list of books for the school library. Most of these books are intended to give the 'atmosphere' of the countries with which they deal but they are primarily for leisure reading. Another appendix describes the operation and maintenance of the film strip and sound projector.

This informative book will be of much interest and value to any teacher of geography or social studies.—J. A. Ross

Man and Resources

WORLD POPULATION AND PRODUCTION. By W. S. Woytinsky and E. S. Woytinsky. New York: The Twentieth Century Fund, 1953.

This is a monumental work. Together with a second volume on world trade, transport and government we shall have, in the words of the Director of The Twentieth Century Fund in the Foreword: 'an effort to put between the covers of two manageable volumes what amounts to a statistical picture of the collective resources, as well as the economic performance and promise of the full array of the nations of the world.' In their share of this stupendous task Dr. and Mrs. Woytinsky have been highly successful.

The table of contents reveals the magnitude of the work. For example, Part IV alone, on Energy and Mining, takes 240 pages and is replete with 99 tables, 68 maps and diagrams, and 262 references. And this is but one of five parts to the present volume. The others cover man and his environment, world needs, agriculture, and manufacturing.

Geographers, and one suspects economists too, will be delighted at the frequent use of maps and the wide variety of cartograms, all of which are closely related to the text. At the same time, they prevent the mass of statistical tables from becoming unwieldy and choking. Thus, this tome is not solely for the specialist but is written, in part, for the layman. Some indication of the coverage of this work has been given in the titles to the five parts. The chapter headings of Part I give further evidence of its range: 'The Earth'; 'Peoples of the World'; 'Migration'; 'Cities'; 'Births, Deaths, Marriages and Divorces'; 'Health'; 'The Future of World Population'.

The approach is in part geographical, and the authors have drawn considerably on geographical writings, particularly in the field of economic geography. Works by Bowman, Pelzer, Finch, Dickinson, Cumberland, Trewartha, Stamp and others are frequently used. Whittlesey's division of the world into agricultural regions is closely followed with respect to subsistence economies.

It is to be expected that, no matter how diligent are the authors, there will be errors in a work of such breadth and depth. New Zealanders in particular will be surprised to find that the dominion has less than ten percent of its population in 'places having 100,000 or more inhabitants' (p. 119). One's faith will also be shaken by the omission of Jakarta, Manila, Karachi, Lima, Teheran, and Istanbul from Figure 42 showing cities of over 500,000 people. Cartographers will find satisfaction in the use of a standard world map and the discussion as to why its particular projection was chosen. They will be pleased with the overall standard of drafting, but they will be shocked by Figures 314 and 315 which are not typical of this work but typical of the sources from which they are drawn.

This is not just a collection of statistics. It is a synthetic and interpretative study of world economic conditions based on statistical sources and measures. The general treatment is historical as well as contemporary, global as well as regional, geographical as well as economic.—W. B. JOHNSTON

WHAT'S WHAT IN BRITISH GEOGRAPHY?

A GEOGRAPHY REFERENCE BOOK. Edited by C. H. Saxelby, Geographical Handbook Committee, Sheffield, 1955. Distributed by the Geographical Association.

The title of this book might lead geographers to believe that here at last is a reference that will authoritatively answer enquiries about geographers and geography in Great Britain. By attempting to satisfy too many tastes within the bounds of about two hundred pages the book has fallen far short of its objective as implied in the title. Nevertheless few geographers will fail to find something of value and most will find much that is of outstanding interest. The fact that contributors are well-known geographers should add considerably to its worth.

This book covers such topics as university entrance requirements and scholarships, institutions and societies of importance to geographers, current sources of reference material and statistics, modern methods in geography teaching, local geography in schools, training and courses for geography teachers and geography staffs of training colleges. And this diverse fare is concluded with a gem of concise and up-to-date condensing in ninety-five pages entitled 'Some New Developments in World Resources.' Professional geographers outside Great Britain may find this, and the first chapter listing university departments and staff members, the most useful sections; and teachers will appreciate the intermediate chapters. But commonwealth geographers and those from foreign countries will look in vain for such things as a list of specific courses in geography offered at individual university departments, entrance requirements for overseas students, possibilities for postgraduate work, assistance available to overseas students, departmental specialities and individual interests and, above all, what research projects are being undertaken at present or what contributions are being made by British geographers to geography.

The book is attractive and well bound and in some ways it is unfortunate that one of the early sections should be four pages of corrections. The committee is to be congratulated on its attempt to produce a reference book. On the other hand it appears rather pretentious to list a thirteen-man handbook committee at the commencement of such a modest volume.—Bryan H. FARRELL

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